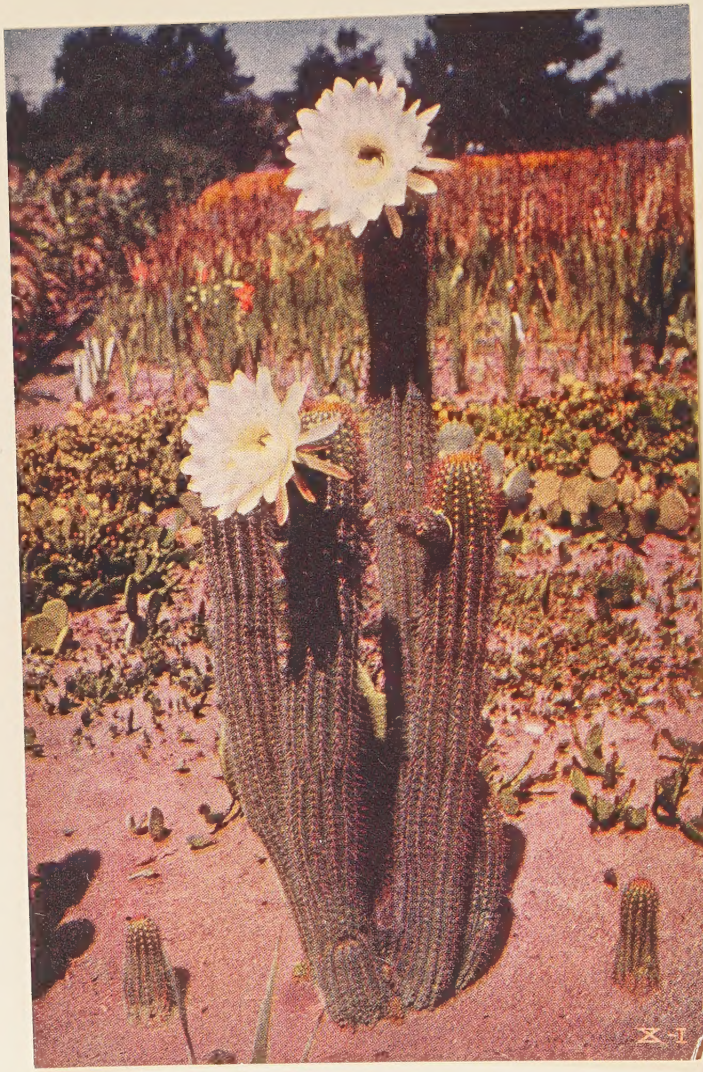

A Selected Night Blooming Cereus

This very fine specimen is the result of careful selection by Mr. Burbank, from large numbers of seedlings. The flowers of this variety are nearly nine inches in diameter. They open early in the morning and are completely withered by ten or eleven o'clock. It will be noted that two of the blossoms on the right hand stalk have withered and that they are marked with strings to indicate that their seed is to be saved for future experiments.

LUTHER BURBANK

HIS METHODS AND DISCOVERIES AND THEIR PRACTICAL APPLICATION

PREPARED FROM
HIS ORIGINAL FIELD NOTES
COVERING MORE THAN 100,000 EXPERIMENTS
MADE DURING FORTY YEARS DEVOTED
TO PLANT IMPROVEMENT

WITH THE ASSISTANCE OF
The Luther Burbank Society
AND ITS
ENTIRE MEMBERSHIP

UNDER THE EDITORIAL DIRECTION OF
John Whitson and Robert John
AND
Henry Smith Williams, M. D., LL. D.

VOLUME X

ILLUSTRATED WITH
105 DIRECT COLOR PHOTOGRAPH PRINTS PRODUCED BY A
NEW PROCESS DEVISED AND PERFECTED FOR
USE IN THESE VOLUMES

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Volume X—By Chapters

Foreword to Volume X

Left in the midst of his flowers, at the close of the last volume, Mr. Burbank in this, the tenth book, continues to unfold before us, more of his transformations.

Beginning with the chapter on the means of securing the utmost variation in flowers, he continues with the Iris, the Tigridia, the Everlasting or Millinery Flower, the Larkspur, and scores of other beautiful flowering plants, more familiar in the average dooryard.

Having covered the range of his flower productions, Mr. Burbank proceds, in this volume, to describe his improvements in ornamental palms and climbing vines, lawn plants and lawn beautification, concluding the book with a terse chapter on practical hints for the betterment of field and flower garden.

THE EDITORS.

The Balloon Flower

The upper specimen shows the form of the flower just before opening, from which the name is derived. It will be seen that the balloon-shape entirely disappears when the blossom has opened, as in the lower figure. This specimen shows the single row of petals characterizing the variety with which Mr. Burbank's experiments began.

Getting the Utmost Variation Out of a Flower

How The Chinese Balloon-Flower Was Trebled

IN illustrating the possibilities of flower development, the case of the Chinese balloon-flower (*Platycodon*) will answer as well as another.

I had been for some time working with a bed of these flowers, with an eye to the increase of their beauty of form, their size, clearness and intensity of color, and the closer and more graceful placing of blossoms on the stalk. As to all of these matters, the existing balloon-flowers left a good deal to be desired.

My method of work was that which I have already outlined so fully in connection with other flowers. The essentials of it, as the reader is aware, are first the careful scrutiny of the entire colony to discover the individual that is the very best of all as to the particular character in question. This individual is selected and its seed carefully preserved.

If the three or four different qualities, improvement of which is desired, are not combined to best advantage in any single individual, then it is necessary to select an individual for each quality, and to carry forward three or four lines of experiment at the same time.

It will be recalled that in developing a special variety of small sweet canning pea, with the qualities of uniform ripening, of small seed, and of seeds of uniform number and equal size in the pod, I was enabled to find these qualities exhibited in such combination that the experiment went forward rapidly, so that in the course of six generations I had developed precisely the variety of pea that was desired.

But it will also be recalled that half a dozen other lines of experiment were carried forward at the same time, using the same group of peas, that led finally to the production of as many quite different varieties, characterized by large size of seed, by lentil-shaped seeds, and the like. And these secondary experiments were carried out without in any way interfering with the primary one. It was merely that, in searching among the different vines, I could not fail to notice individual plants that showed interesting characteristics, and nothing more was required than to mark these differently from the others and save their seed.

Double Balloon Flower

This picture, like the preceding one, shows both the balloon-shaped buds and the open flower. But this is a developed variety, in which the petals have been increased in number through the methods of selective breeding described in the text.

So in such a case as that of the balloon-flower, where it is desired to increase three or four quite different qualities—in this case size, beauty of form, manner of placement of blossoms, and intensity and clearness of color—it does not so very greatly matter whether in the early generations one finds the different qualities combined in a single individual, or whether, as is more likely, he finds one individual that is most graceful, another that has blossoms placed on the stalk in the best manner, and a third that shows to best advantage as to intensity and clearness of color.

It is much more probable, in practice, that the second alternative will be the one actually presented. Indeed, it is altogether unlikely, when new qualities, such as these, that have not hitherto attracted the attention of the cultivator of the plant, are in question, that one will find a single individual that surpasses all its fellows as to each quality.

In point of fact, with the balloon-flowers, it was necessary to save seed of three or four individuals and search among their progeny in turn in the following season, and make additional selections that involved a number of individuals.

But when selection has been carried to a stage where we have one race of balloon-flowers presenting plants that are uniformly of graceful and attractive form, and another race that has the

flowers arranged in a satisfactory way on the stalk, and a third race that produces flowers of a brilliant white color, the materials are in hand for an amplification of the experiment along lines with which the reader is already familiar, through which the desired combination of these traits in a single race may be effected with almost absolute certainty.

The Combination of Qualities

The method in question consists, of course, in cross-pollenizing the best individuals of the three new races. Of course, one cannot blend three strains in a single cross-pollenizing experiment. But one can cross-pollenize specimens of each one of the three with each of the others, making the cross reciprocal in all cases to make quite sure. Each of the new hybrid races will thus blend, in one way or another, the traits of two of the parent forms.

Selection being made to find the best types among these two crossbred races, the ones selected will, of course, be inter-pollenized and their offspring, representing the second generation from the three parent forms, will combine all the hereditary factors of their three specialized ancestors.

Among these second generation hybrids there will be found, in all probability—if large numbers of specimens are examined—some individuals that

Single and Double Balloon Flowers

At the balloon stage, the single and double varieties look exactly alike; the double one being, in point of fact, one balloon within another. On opening, the extra petals are revealed. Note the different color variations as contrasted with the preceding picture.

will combine in the superlative degree the qualities of gracefulness of vine of one grandparent with the satisfactory arrangement of flowers of the second grandparent and the brilliant whiteness of blossoms of the third grandparent.

It is then an obvious procedure to save the seed of this individual, and while we must expect wide variation among the plants grown from that seed, there will almost certainly be some among them that will reproduce the combined good qualities of the parent, and further selection along precisely the same line—what I sometimes speak of as "line breeding"—will result in fixing of the type, so that we shall have the variety, hitherto existing only in our imagination, which we have all along been seeking to produce.

Moreover, not alone shall we have produced a type which combines all the best qualities of the different members of the original balloon-flowers, but our new race will almost certainly present these characters in markedly accentuated form. The perfected balloon-flower will be more graceful in form than the most graceful one of the original colony. It will have its blossoms much more artistically grouped on the stalk than any balloon-flower that has hitherto been seen, and the color of these blossoms will be cleared and more brilliant than those of any individual member of the

original colony, whether blue, white, or intermediate, as may readily be demonstrated by comparison if the original colony has been preserved, and is now represented by unselected progeny.

Of course, in my own experiments, the unselected members would usually have been destroyed, but the worker who experiments on a smaller scale may find it desirable to preserve the old colony, or some members of it, if for no other purpose than to find encouragement in making such a comparison as that just suggested.

The results, as I have said, are sure to be encouraging if you have carried out the experiment in the way just outlined. Nothing more is required than the use of your eyes and reasonable judgment in selecting the best specimens; care in the preservation of the seeds; cultivation of the seedlings in the way we have elsewhere fully described; and persistency in following up the experiment.

I have a good many times pointed out that in such experiments there may not be very much encouragement in the first generation or two. Some forms of plant, and in particular those that have not been very much under cultivation, or that are represented by only one or two species, may hold fixedly to their type and show at first only a slight range of variation. In such cases

Double, and Tending Toward Tripleness

Here the tendency of the balloon flower to increase its petals has taken on another phase, in that there is a rudimentary third row of petals, represented by a transformed stamen. This obviously is promising material for further experiments.

you must be content to go forward by very slow stages, taking but the shortest step ahead with each generation for the first two or three years.

But even where progress is as slow as this in the beginning, the time will almost surely come when the effect of what I have several times referred to as the momentum of variation begins to be felt. Some season, to your surprise and delight, you will discover that the plants are varying much more widely than they have done hitherto.

Instead of having to scrutinize your seedlings with the utmost care to determine which ones are largest and most vigorous; and then in turn scrutinize with equal care the blossoms—when they appear—to determine which are largest and most brilliant, you will find that some few seedlings will jump ahead of the others as if they belonged to another race, bringing to your mind the familiar tale of Jack's Beanstalk, or the less familiar story of Darwin's Hero morning-glory, which appeared suddenly after several generations of selection.

When the seedlings which thus practically select themselves have come to blooming time, your delight will be enhanced as you discover that the blossoms they bear are markedly larger and more brilliant than any you have seen before.

Now all your disappointment and discouragement of the first day is forgotten. Now your enthusiasm is reanimated and accentuated. From this time forward you carry on the experiment with renewed zeal, and you feel confident at last that the coveted goal is within sight.

Plants That Tend to Vary

Of course there are other plants that give encouragement from the very outset. Such is the case with almost any of the familiar cultivated plants, of which there are many species and varieties that have long been given attention by the horticulturist.

Suppose, for example, that you were to plant all the seeds taken from the seed pods of a single dahlia. Perhaps you have done this on occasion, not with any thought of making new experiments or developing a new variety, but merely in the hope of reproducing the characteristics of the best and most beautiful dahlia among the number in your garden. In that case you have doubtless been subjected to bitter disappointment. For when the carefully nurtured seedlings came finally to blooming time, instead of presenting flowers closely similar to those of the parent form, they have shown, in all probability, the widest range of variation—not one of them perhaps has been closely similar to the parent. Nor, perhaps, were any two pre-

Yet Another Step Toward Tripleness

With this balloon flower several of the stamens have turned into petals of a rudimentary type. If carefully selected, the progeny of this flower should, within a generation or two, have some representatives with three rows of fully formed petals, in striking contrast with the single-flowered parent-forms a few generations removed.

cisely alike. Among them you could discover resemblances to all the other dahlias in your garden and, indeed, to a large proportion of those that you had seen pictured in the seed catalogues.

In a word, your dahlia seeds show that they contain the racial strains of a great variety of ancestors, and they present a variation that is truly disconcerting to the gardener whose sole desire was to produce a lot of dahlias of uniform character.

In one case, recorded by Darwin, an experimenter listed no fewer than eighteen different varieties of the dahlia grown in the first generation from the seed of a single plant, and of course there were all manner of intermediate forms. In the listed eighteen only six corresponded pretty closely to certain named or catalogued varieties. It would perhaps more truly present the record if we were to say that there were not eighteen different varieties merely, but as many varieties as there were individual plants.

But while such an experience as this is utterly disconcerting to any amateur whose only thought is to produce a bed of flowers of uniform color or character, the same experience would offer precisely the opportunity that the would-be developer of new varieties is seeking. Now it is not a case of hunting here and there throughout a company

of seedlings for one that differs by a shade from the others. It is a case of selecting two or three or a dozen individual plants that present features that attract the experimenter; and selecting their seed to be planted the following year in individual plots, that the experiment may be carried forward, generation after generation, just as before so far as principles are concerned—but very differently as regards results, inasmuch as now there is the most striking departure in each successive generation from the characteristics of the parent form.

How wide the departure may be within a few generations is well manifested by the dahlias, since these plants, as we have already learned, have all been developed in the space of about a century from wild originals. Moreover, by no means are many generations represented as might be supposed, inasmuch as the dahlia is propagated usually from the bulb, and it is only now and again that an experimenter has taken the plant in hand to raise it from the seed and separate out new varieties.

That a plant which in its wild form is an ordinary sort of composite—not very different from the Black-Eyed-Susans and allied sunflower-like plants that abound by every roadside—could be developed in a comparatively short series of generations into the extraordianry flower with solid

Work with the Calendula

Mr. Burbank has a large bed of these flowers in his garden now, and in recent seasons he has been testing it with an eye to the range of its possible variations. It is a flower with which any amateur may work readily and to advantage.

heads, and presenting the gorgeous and variegated colors of the dahlia of to-day, is in itself an object lesson in the possibilities of plant development that is nothing less than inspiring.

Unexpected Results

Not only may plants be led along the line of some desired variation, but there is an element of chance in the enterprise that adds very greatly to its interest.

There is always a certain allurement about the happening of the unexpected. It is highly gratifying to select a plant for some desired quality and to have it respond to selection in such wise that a variety presenting this quality is finally produced. But it is doubly gratifying to see here and there, quite unexpectedly, the putting forth of a flower of an unpredicted color, or the development of a form of which one hitherto had no conception.

In a field of cultivated poppies, for example, where there were millions of specimens, all of substantially identical color, so that the field made a blazing sheet of yellow, I have come upon a single blossom of the purest white.

To find this white blossom, isolated among the millions, is an experience that repays one for years of earnest effort and makes amends for almost any antecedent disappointment.

It was such a chance discovery as we have seen

that gave the world the wonderful new race of white Watsonias. Quite possibly the white flower that Mr. Arderne found among the colony of reddish pink ones may have been the only one of its color among a million, or perhaps ten million, of its fellows for miles around. But this single atypical individual chanced to be discovered, and its progeny to-day are found by thousands, even by hundreds of thousands, in the gardens and greenhouses, not alone of its native home in South Africa, but of all parts of Europe and warmer regions of America.

I myself, as the reader will recall, have raised these white Watsonias by hundreds of thousands. Their strains were mingled in the germ plasm of the quarter million bulbs of this species that I was obliged to destroy in a single season.

Such are the possibilities of multiplication of a plant. Such is the geometrical ratio at which the offspring of a single individual increase if given encouragement. Boundless, then, are the possibilities that lie before the plant developer who discovers a single specimen of an aberrant type. One white poppy among the million yellow ones might be the progenitor of a race that would displace entirely the whole race of yellow poppies.

What I wish to illustrate at the moment, however, is not the possibilities of multiplication of

Educating the Calendula

Contrast this picture with the preceding one. Even the flower at the left has multiplied its petals many times; and the middle flower and the one at the right show successive stages of the filling up of the center with ray flowers.

the plant but the interest that attaches to the development of unexpected variations. And I repeat that the possibility of finding a new form in your flower garden almost any morning will give perpetual interest to your task, and will come to be a compelling incentive that will take you to the garden as steel is drawn to the magnet.

To illustrate the possibilities from the case directly in hand, let us recall the new race of balloon-flowers, the evolution of which we have just traced. I have said that the experiment began with the ideal of a balloon-flower of better form, more graceful placement of flowers, and individual blossoms larger and of more brilliant color. I have said also that these ends were in due course attained, and have traced briefly the steps through which the new race of perfected balloon-flowers was evolved.

Now it remains to add that when the experiment was approaching completion, and a new race of balloon-flowers in many ways satisfactory was actually in being, I discovered one day among the blossoms one that had a perfectly regular second row of petals, instead of the usual single row, or the irregular so-called double, which had sometimes appeared. Here was an unexpected variation, which was something that I had not counted on or considered.

A Bed of Burbank Calendulas

Here we observe remarkable variation in color, size, and fullness of flowers. There is almost boundless opportunity here for experiments in selective breeding. It would be interesting to see how many types of new varieties of Calendulas could be developed from this single bed.

But, needless to say, I hailed the new arrival with delight, and marked it for further education.

If we ask why this second row of petals appeared, the answer can be only a conjecture. Doubtless some condition of altered nutrition stimulated the plant to this abnormal production. It is customary to speak of such an anomaly as a "sport" or mutation. But doubtless these words beg the question. They name a condition, but do not in any way explain it.

It is an observed fact, however, that sudden variations analogous to this may be stimulated by a change of climate or a change of soil, as when a plant is brought from another hemisphere, or by a surplusage or a shortage of food. It is familiarly known that in a beehive the larva that would otherwise grow into an ordinary worker may be made to develop into a queen, that is to say, a mature female, by forced feeding. In somewhat the same way a plant that has an excess of nourishment may tend to take on exceptional growth, and one manifestation of this might be a disturbance of the equilibrium of the floral envelope, with the production of an unusual number of petals.

It is known, on the other hand, that a shortage of food supplies or disadvantageous conditions of climate may hasten the maturing of a plant, and

cause it to fruit earlier than it otherwise would do. And any disturbance of equilibrium of this sort may lead to anomalies in the precise character of the flower.

Possibly the reason why the petals of the flower are most likely to be altered as to number, and also as to color, is the fact that these are about the newest of all the plant structures. We have seen that the petals are not themselves essential to the fertilization of the plant—they are only advertisements to attract insects. They were developed late in the evolutionary history of the plant, and their variability is an additional evidence of their modernity. The fact that so many of our cultivated plants have become "double" is in itself sufficient proof of the tendency of the petals to be modified under conditions of change of climate and nutrition to which the cultivated plant is subjected.

But from our present standpoint, what perhaps is of greatest interest is the fact that when petals have once shown a tendency to such modification, this propensity is heritable, and the progeny of the plant will reveal some members at least that show the same characteristic.

Moreover, the "momentum of variation" to which I have so frequently referred will make itself felt in the tendency of these variants to take

A Promising Pupil

Here is a Calendula flower selected from among those shown in the preceding picture because of its tendency to produce rudimentary rays in the composite center of the flower. There is a love of change inherent in the germ plasm of this individual, and its progeny will be worth watching.

on still wider variation. In other words, the plant that has developed an extra petal or row of petals has in its germ plasm factors that will tend to urge it to the production of still greater modifications of the floral envelope.

In the case of the balloon-flower, the plant that had developed a second row of petals, when its progeny were carefully scrutinized, was found to have transmitted the anomaly to a certain number, and among the progeny of these there presently appeared one that had a third row of petals. So in the course of comparatively few generations there had been produced a race of balloon-flowers that had trebled the number of petals that hitherto had been the recognized complement for flowers of this race.

Multiplication of petals may result, as we have already noticed, from the transformation of stamens into petals, or it may come about from the springing into being of new petals *de novo,* rather than as modifications of any pre-existing part of the flower. The latter appears to be the case with the new rows of petals of the balloon-flower.

Whether the modification will continue until the balloon flower has a large number of rows of petals, comparable to those of the double roses, for example, remains to be seen. But at the present stage the flower has a triple corolla, constitut-

Another Stage of Progress

Here is a calendula flower that has progressed a step farther. It is much larger, and its center is more nearly filled with ray flowers. It bears but a remote resemblance to its progenitor of the type shown in the first picture of this series a few pages back.

ing a very striking modification. The ultimate limits of its variation can be determined only by further series of experiments.

Stimulating Variation

The modification of the balloon-flower has somewhat exceptional interest, because there is only a single species of the genus *Platycodon,* to which it belongs, anywhere in the world.

In other words, this genus is what is called a monotype, and it is a well-recognized fact that flowers belonging to a genus having only a single species, and even to genera having half a dozen species, are relatively little subject to variation. Rightly considered, this is almost axiomatic; because the very fact that there are many species in a genus proves that the representatives of that genus have been variable; else they would not have developed so many different forms, since all members of a genus have sprung from the same ancestry within comparatively recent times.

The balloon-flower has seemingly been isolated under climatic conditions that have not greatly changed for a long period and hence it has maintained its specific identity, and the type has become thoroughly fixed. And this fact, as I said, gives added interest to such an experiment as that just outlined, which shows how marked may be the developments that can be produced by selective

Still Another Calendula Variation

In this specimen the ray flowers are still more crowded, and the center has been minimized, although still capable of producing a certain number of seeds. If the seeds were entirely eliminated, of course the experiment in selective breeding could go no farther.

breeding, even with a flower that tends very strongly to maintain fixity of type.

But, in point of fact, as we have emphasized again and again, no flower is so fixed that it does not vary to some extent; and in the case of the balloon-flower, it appears that there are modifications in the type of the plant as it appears in China and in Japan, that are sufficiently divergent to be recognized by the botanist as established varieties. A form from Manchuria also has been modified, particularly in the matter of the time of blooming, which is much later than that of the type species. Also in the matter of color—that most variable of traits—there is modification, as some varieties are blue, some bluish white, and some variegated, in addition to the pure white form.

There was, however, no other color until last season, when a plant bearing large red blossoms appeared among a few thousand seedlings which had been grown from my long-selected varieties.

There is material at hand, then, through which cross-fertilization may be practiced, with the possibility of giving the flower still greater impetus to variation. Until such cross-pollenizing has been practiced, using varieties of the plant imported from the most widely spread regions—let us say races grown in China, in Manchuria, in Japan, in Europe, and in California — we shall not have

A Calendula of Real Distinction

This specimen is approaching the limits of variation in the direction toward which it has been specialized. Note the fringed character of the ray flowers, and their exceedingly symmetrical distribution, like shingles on a roof.

tested fully the possibilities of variation of the balloon-flower.

And indeed, even when these crosses have been made, there will still remain possibilities to invite the plant experimenter. For although the balloon-flower stands in a genus by itself, there are of course other genera that are not very distantly related in the Campanula family, to which the flower belongs. The balloon-flower is often spoken of as the Chinese bellflower, and with entire propriety, inasmuch as its nearest relatives are the European and American bellflowers, of which there are several familiar species, the best known, perhaps, being the one called popularly the harebell or bluebell, and the Canterbury bell.

It is quite supposable that it might be possible to hybridize the Chinese flower with one or another of these European or American bellflowers.

And in that event it is not to be doubted that the hybrid race would show new possibilities of variation and, by combining ancestral traits that have not been blended since remote geological periods, if at all, we should develop among the progeny of the balloon-flower races that would, in all probability, differ so radically from the parent form as scarcely to be recognizable as having any relationship whatever with the plant with which our experiment began.

Extreme Development of Another Type

This calendula, like the preceding one, represents something like the limits of variation in a given direction; but in this case the variation is of a different type from the other. Here the rays are long and graceful, and the flower is less compact in form, though not lacking in distinction. The two flowers, like the others shown, have been selected for different qualities from among the progeny of the same remote ancestors.

All of this, of course, is taking liberties with the future. In the case of the balloon-flower, such hybridizations have not as yet been successfully carried out. But in suggesting the possible results of such potential hybridization, we are merely drawing analogies from almost numberless experiments with other races of flowers, and we have every warrant for drawing such conclusions as those just suggested. Certainly we are justified in the conclusion that we have not tested to the fullest the possibilities of variation—that we are not by any means "getting the utmost variation out of the flower"—until we have supplemented the method of selection with that of hybridization.

I may add that there are yet other possibilities of stimulating variation by chemical treatment of the developing ovaries of the flower itself; or by subjecting the plant to unusual conditions of hothouse temperature; but experiments of this type, reference to which has been made in an earlier chapter, have not fallen within the scope of my own work, and as yet have been carried out only tentatively by others. So I mention them here only as suggesting that there are other possibilities so various and so complicated as to give full assurance that no single line of investigation will ever reach a stage where it loses interest because it has brought the investigator to the end of the road.

Improvements in the Much Improved Iris

And a Few Other Old Favorites

IF you are disposed to undertake a series of practical experiments along the lines suggested in the preceding chapter, it is by no means necessary for you to send to distant countries for the material.

Of course, the professional plant developer is always on the lookout for plants from China and New Zealand and such far-away places. But the amateur need not be deterred by the difficulty of securing such materials. It suffices perfectly for him to go into his garden and begin his experiments with the first flower he chances to find there.

Any old-fashioned flower garden, such as adorns the door-yards of millions of homes in America, will furnish abundant material for all the experiments that any amateur need care to undertake.

Let me name almost at random a few of the

common garden flowers that offer interesting opportunities for development, and any one of which will serve quite as well as another for the commencement of your tests of the possibilities of plant development. Take, for example, the familiar iris, known sometimes as the rainbow plant. There are specimens of it, in one variety or another, growing in every garden. It makes its way if given the slightest opportunity, and its somewhat lily-like flower with the graceful recurved fringed petals has retained its popularity generation after generation, notwithstanding the coming of many new favorites.

My own work with the iris has had to do largely with a Japanese species known as *Iris laevigata*. On an acre of damp ground that I have at Sebastopol, I raised great quantities of these flowers a few years ago. The combination of colors was beautiful beyond description, varying in all shades of the rainbow. Among the seedlings were numbers that produced double flowers, and sometimes the double ones took on handsome and unusual shapes, in other cases the anomalies of form were grotesque and even monstrous, rather than beautiful.

Some of the seedlings produced almost ten times as many flowers as others, the individual blossoms being of equal size. Some were tall and

The Iris

This common and familiar, but very beautiful, garden flower is one that makes particular appeal to the amateur, and with which experiments in selective breeding, notably with regard to color-variation, may be made. This specimen is from Mr. Burbank's experimental garden in a recent year.

lanky and could hardly support themselves when in bloom. Others were short and compact. The range of variation was from dwarfed forms of eight inches to giants of four feet or more.

And that the variation was due to heredity and not to any environmental conditions was shown by the fact that the dwarfs and giants might stand side by side in the same soil and subject to precisely the same conditions of moisture.

There was not much demand at that time for new varieties, so I ultimately sold the entire lot of hybrid Japanese iris as a mixture, without names or numbers, not taking the time to sort out and fix different types by selective breeding.

In addition to the Japanese form, I have raised a great number of other species, including one interesting form in which the seed pods turned out in a curious way and exposed the orange or scarlet seeds. This is a species known as *Iris foetssissima.* I grew this anomalous form extensively to produce a race that would have seed pods and seeds that would have better form and open more fully.

It is not necessary to go into details as to the score or more of other species that I have grown, as they all reveal more or less similar tendencies to variation, and suggest over and over the same possibilities of development.

Graceful and Attractive

Mr. Burbank's experiments with the iris have been made largely with the Japanese variety; but he tells us that there is ample opportunity to do good and interesting work with the varieties that are found in any garden. Contrast this specimen, with its graceful drooping petals, for example, with ones shown in succeeding pictures. Obviously, here is ample material for selective breeding.

It does not matter very much, then, what particular variety of iris is growing in your garden. Probably there are plants that bear purple flowers, others with yellow ones, and yet others that are white. This obviously gives you opportunity for hybridizing, and there will be abundant interest in watching the results of the blending of different colors.

If at the same time that you are crossing the iris of different colors you save also seed from other plants, or from different flowers on the same plants, that are not crossed, you will be able to check the results of your experiment, and will find yourself launched at once into an investigation that offers fascinating possibilities. It should be explained, however, that the cross-pollenizing of the iris presents complications which will not be solved unless you make a very careful inspection of the flower.

The stigma of the flower has a little lip under the unique petaloid pistils, very different in appearance from the organs of most other flowers. If you examine it closely you willl see that the little shell-like lip that projects is adjusted in just the right way to scrape pollen off the back of a bee as it enters the flower, or similarly from the head of a humming-bird. The arrangement is such that the bee or humming-bird will come in

A Broad-Petalled Iris

The form of the iris is characteristic, and there is not as wide variation in this regard among the different varieties of this tribe as among many others. Yet the form of the petals may be very conspicuously modified, as this specimen shows. Interesting studies in form variation might be made by crossing such a specimen as this with the one shown in the preceding picture.

contact with the pollen of an individual flower only after it has passed the pistil, and the protecting sheath prevents the deposit of pollen as the insect or bird leaves the flower. Thus it is insured that self-fertilization will not take place.

While the flower is, as I said, complex in this regard, nothing more is necessary than to study its mechanism attentively, pulling to pieces two or three blossoms to see just how the pollen must be deposited. After that you will experience no difficulty in cross-fertilizing the iris, and the results of your work are sure to be of interest.

Four-O'Clock and Columbine

The familiar four-o'clocks are all natives of America, but most of them had their original home in the sub-tropical and tropical portions of our continent. There is one, however, that is native to California, and various species made their way to the gardens even far to the north a century or more ago, and are now grown everywhere.

The most striking peculiarity of the four-o'clocks is their tendency to combine different colors in the same flower in peculiar patterns.

We have seen a great deal of color variation among flowers. We have seen numberless instances in which blossoms of the same species may be in one case red, in another pink, in a third yellow, and in a fourth white. We have seen also

some instances of the mingling of different colors in the same flower, notably with some of the dahlias. But our attention has been called to no flower that mingles the colors in quite so anomalous a way as is characteristic with the four-o'clocks. For these blossoms, seemingly unable to decide between different colors, have hit upon a compromise of arranging the colors in definite stripes, which give the tubular corollas a very curious and characteristic appearance.

In a lot of seedlings, supposedly of the same variety, the stripes may come in various widths of white, crimson, and yellow. Even when the seed is saved from a single plant, there will be great variation among the seedlings, in some the wide white stripes predominating, in others the crimson, and in yet others the yellow. Again, some of the flowers may come pure white, or yellow, or crimson, or pink, quite without stripes; or perhaps half of the blossoms on a given plant will be one color and half another.

It is obvious that a plant showing such wide variation does not call for hybridization to stimulate variation. The mingling of hereditary strains is already sufficiently complex, and you will find quite sufficient occupation in attempting to sort out new races of a good color or combination of colors, and in fixing a dozen of them so

A Spectacular Iris

Color variation is, of course, the most conspicuous characteristic that will appeal to the amateur in the case of the iris. There are purple iris and yellow ones and white ones in almost any garden, and these may be combined in endless ways. Here is a specimen that shows an interesting and spectacular color-blending.

that they will come reasonably true to type. If you succeed in accomplishing this, in the course of a few seasons, you will have performed an experiment that you will find full of interest, and your task will not have been carried out without giving you very suggestive sidelights on the problem of heredity.

It is, in any event, a very curious anomaly that a plant should so have assorted its hereditary factors that they adopt this compromise. And your investigation, which endeavors to determine how accurately the tendency to striping is dependent on particular combinations of hereditary factors, will not only prove interesting, but may lead to valuable revelations. The entire problem of the study of heredity of color, notwithstanding the attention that has been given it, still bristles with unanswered questions. Your experiments with the old-fashioned four-o'clock may serve to give you answers to some of them.

A somewhat simpler but perhaps no less interesting problem in color heredity may be taken up in connection with the equally familiar columbine.

There are thirty or more species of the genus *Aquilegia,* or tribe of columbine, and examples of one or two of the more common ones are sure to be found in your garden. At least you can get seeds from which to grow them at any florist's.

I have always been fond of the columbines because of their numerous species, and their wide range of color variation; also because of the curious shape of the flower and the tendency of the spurs to vary greatly in length, as well as in their tendency to open out in some cases, and in others to remain partially closed. There is, indeed, one old cultivated variety which has lost the spurs altogether.

I made at one time some interesting experiments with this spurless kind of columbine, crossing it with many others, especially with one known as the *coerulea,* which has very large flowers of beautiful shades of blue. The hybrids of this spurless form with the other species produced beautiful large climatis-like flowers, some of them three or four inches in diameter.

Perhaps the most interesting feature of the experiment was that the hybrids were entirely spurless. This shows that the condition of spurlessness, which is an anomaly presumably of recent origin, inasmuch as the spurs are a characteristic feature of the flowers of the wild columbines, acts as a dominant factor in heredity. This, of course, is what should be expected if it be true that the newly developed characteristics of a plant are dominant over the older ones. But the case of the columbines furnishes another interesting cor-

A Round-Petalled Iris

Contrast this specimen, with its almost circular lower petal with the ones shown in succeeding pictures. The characteristic iris traits are present throughout; but the modifications in form of petals, and in the relative sizes of the different petals, are very conspicuous.

roboration of this interpretation of Mendelian heredity.

In the course of other experiments with the columbines numerous other species were brought into the combination through successive hybridizations, until my columbine colony carried the strains of more than a dozen recorded species. A most beautiful lot of hybrids resulted. Their various members revealed nearly all the colors of the rainbow. I introduced them to the trade as mixed varieties, as it did not seem to be worth while to fix the different types. On the contrary, the variety of blossoms seemed to be considered an advantage.

But, in point of fact, even if it had been desired to fix the new types, it would have proved exceedingly difficult to do so. When you have two or more species of columbine in combination, the hereditary complications are comparable to those in the gourd family, to which we have had occasion to refer. It seems as if every member of a fraternity differs from all other members, and you cannot be at all sure as to what results you may attain by sowing seed from any individual plant.

But these complications result in part from the fact that the different columbines are so easily crossed by the bees. This is a case where there is no difficulty in effecting hybridization; the diffi-

An Iris with Pointed Petals

Here the petals have been modified so that they are pointed instead of round, and their texture is quite different from that of specimens shown in the preceding pictures. Such matters as these have great interest for the gardener, but are probably not vital from the standpoint of the economy of the plant itself; hence they are particularly subject to variation, affording the plant breeder precisely the opportunity he is seeking.

culty is to prevent crosses that are not desired. If the plants are shielded from the visits of the bees, and careful hand pollenizing is effected, there is no great difficulty in combining the different forms in such a way as to get definite results, and the hybrid forms may be fixed by careful selective breeding.

Of course, when you deal with a spurless form, if the individuals that you use are themselves hybrids of the first generation of a cross between a spurred and a spurless variety, their progeny, when they are crossed with a spurred variety, will be in effect second generation hybrids and only half of them will be spurless. But this, again, merely illustrates the familiar segregation of characters and the reappearance of the recessive trait —in this case the spurred condition—in a rather definite proportion of the second generation progeny.

Another anomaly among the columbines that offers good opportunity for experimental tests is furnished by the double varieties. I used to notice that if you crossed a double and a single one, you are about as likely to get a double as a single. Here, again, it would appear that the double condition of corolla acts as a Mendelian dominant factor, and that the strains with which I worked were themselves mixed.

A Difficult Flower to Cross-Pollenize

To casual inspection, the iris does not appear to be a perfect flower. That is to say, it seems to lack stamens and pistils of the ordinary type. In point of fact, the iris has organs of fertilization that are quite petal-like in appearance, arranged in such a manner as to provide against self-fertilization. But intelligent inspection will enable the would-be pollenizer to solve their mysteries without great difficulty.

All in all, then, the columbine offers most interesting possibilities for the experimenter who likes to test for himself the principles of heredity. In the matter of color, there is the widest variation, some of the familiar forms being blue, others red and yellow. The curious spurs that characterize the flower, and the fact that some varieties lack them, furnish tangible features that may be tested, and the single versus the double corolla constitutes a third feature that is also susceptible to definite observation and record.

So the experimenter who will work with a small number, differing as to characteristics of color and spur and doubleness, has opportunity for watching the interplay of hereditary forces; observing the dominance of certain hereditary factors, and the recessiveness of their opposing factors; and finally the segregation of the different characters and their reassembling in new combinations in the second generation, that will test his knowledge of the principles of heredity to the utmost, and at the same time will give him definite ideas about the practicalities of plant development that will be at once interesting and valuable.

Meantime the experimenter may introduce problems of far greater complexity if he so desires by mixing larger numbers of the plants somewhat at random, and allowing them to be cross-fertilized

by the bees. In this way he may secure, as I have done in some experiments, columbines of the most wonderful variety. In some of the mixed hybrid colonies, the blending of hereditary factors was so complex that among ten thousand plants there would be perhaps not five hundred that could be classified as approximately identical with one another, or as conforming to a specific type.

In other words, there would be perhaps nine thousand five hundred individual plants, each of which might be said to constitute a distinct variety.

In the course of these experiments I made perhaps ten thousand careful hand pollenations between different specimens of these variant hybrids, and, needless to say, secured plants with exceptional blossoms of many kinds.

A similar line of experiment is open to anyone who has the smallest plot of ground in which he can grow a few scores of columbines.

Campanula and Coreopsis

If you were to seek experiments of a still simpler character, you might do well to consider the beautiful campanula, known familiarly as the bluebells of Scotland.

These are hardy flowers, growing wild in great profusion, even far to the north. On a trip to Canada a good many years ago I was delighted to

An Ingenius Mechanism

The stigma of the iris has a little lip under the unique petaloid pistils, adjusted in just the right way to scoop the pollen off the back of a bee as it enters the flower, or from the head of a humming-bird. The bee or humming-bird will come in contact with the pollen of this flower only after it has passed the pistil, and the protecting shelf prevents the deposit of pollen as the insect or bird leaves the flower. It is a most ingenius and interesting arrangement.

see great fields of companula as far north as Alberta. They are said to grow even in Siberia. So whatever the location of your garden, you will probably have no difficulty in raising bluebells. The plants, to be sure, are somewhat subject to the attacks of fungus pests and insects, but aside from this difficulty they are easily grown. It goes without saying that a flower that has become famous as the "bluebell" is generally blue in color. Yet it is by no means unusual to see specimens that are pure white. And it is this variation that gives opportunity for some simple experiments in cross-breeding.

Nothing more is needed than to secure plants of the ordinary blue variety and others that bear white blossoms. The campanulas are easily crossed, and you will have opportunity to test the color variation in heredity in some of their simplest relations. There are, to be sure, many species of campanulas, and it is true that the garden varieties are likely to have been hybridized. I have, for example, raised seedlings from the white campanula, *Rotundiflora,* without securing any white ones. It will be necessary, therefore, for you to test your varieties by raising plants of uncrossed seeds at the same time that you are making the cross-pollenations. But this complication will only add interest to the experiment.

The many tribes of coreopsis give opportunity for experiments of equal interest. These plants are composites, and in hybridizing them it will be necessary to use the method detailed in our story of the dahlia, washing away the pollen before applying pollen from the other flower.

The different members of the family vary in color from deepest purplish crimson to light yellow and white. There are numerous species under cultivation, and there are wild ones growing as roadside weeds that are readily accessible. The variability of the different races makes them an interesting race with which to work.

My own work with the tribe has included a good many species, the most important of which is the one known as the *Coreopsis linceolita.* The experiments look to the increase of the number of florets, as well as to the size of the flowers and abundant bearing. I also had in mind improving the form of the plant. There was no great difficulty in doubling the size of the flower, and in the course of four years, working with seed purchased in the common market, varieties were produced that were considered worthy of introduction, and that were distributed by several leading florists.

The developed varieties had exceptional value because of the large size of the flowers and of the small center; also because of the long stems, mak-

A Luxurious Type

There is something peculiarly oriental and luxurious about the appearance of this particular variety of Burbank iris; the idea being carried out by the richness of coloration and the softly-flowing contour of the petals. In point of fact, however, the oriental iris is of a somewhat different type, as will be seen in succeeding pictures.

ing it a good flower for cutting. A fault of many of the annual varieties is that they have small, weak stems.

As to all of these matters, the amateur can work by selection and by hybridizing. The wide range of color variation affords a ready guide in hybridizing experiments, and the ease and certainty with which the plants can be grown from seed adds greatly to their utility from the standpoint of the amateur.

Shooting Star and Salvia

A really fine plant that offers opportunity for improvement, yet which has been little worked with, is the Shooting Star, sometimes called American cowslip, a member of the primrose family, classified under the genus *Dodecatheon*.

There are sixteen or eighteen species described in botanical literature, yet so great an authority as Asa Gray thought that all the *Dodecatheons* in the world should be classified as one species. There are remarkable variations in size and color, however, yet the varieties are sufficiently fixed to offer good opportunity for experiment, and at the same time are closely enough related to that they may readily be crossed.

The flowers of the various types show the widest variation—dark purple, crimson, rose, white, spotted, cream color, and yellow. There is oppor-

A Japanese Iris

Mr. Burbank's experiments, as already mentioned, have largely had to do with the Japanese iris. He raised great quantities of them at Sebastopol a few years ago. The combinations of colors are beautiful beyond description, and they vary in all shades of the rainbow. Sometimes the double ones take on handsome and unusual shapes. These are typical specimens of a more usual form.

tunity for sorting out individual colors and their fixing through selection; and, on the other hand, for the combination of colors to produce new shades.

The plants are handsome, and they furnish admirable material with which to work, not merely by way of gaining experience, but also with the possibility of producing worthy new varieties.

The Salvia are members of the mint family. There are many species, showing a wide range of variation. The commonest one is known in every garden for its brilliant red flowers borne in such profusion as to make splendid masses to group along walls or as borders. There are other salvias, however, that have charming light blue flowers. The plant in the ordinary gardens is grown, of course, only for its flowers, yet there is a species, known as *Salvia sonomensis,* or *Salvia ramona,* that is abundant on some of the hillsides in California, and that is to all intents and purposes identical with the cultivated sage. Its foliage has the exact flavor of that of the cultivated plant. I have at times thought of growing it to see if there could not be developed from it a sage that would be more valuable for seasoning than the one under cultivation. The common sage runs into numerous varieties, some woolly leafed, some golden leafed, and some with tri-colored leaves.

Seedling Japanese Iris

This is one of a multitude of variants among the seedlings of the Japanese iris. It is probable that these plants were stimulated to vary by the change of climate and soil. We have seen numerous illustrations of similar effects of a changed environment.

It is possible that by hybridizing this plant with the wild variety improvement would be made in the unique quality for which its leaves are prized.

From the present standpoint, of course, our interest in the salvias concerns their flowers. I have done a great deal of work with various members of the family, both in the way of selection and of hybridization. The plant is tremendously variable, even within the same species, and the various forms run more or less together so that it is difficult differentiating them botanically. But the contrast between the species bearing blue flowers and the familiar garden plant with its scarlet blossoms is striking enough to challenge the attention even of the least observant.

The fact that the various species can readily be hybridized, while at the same time they show such variation as to color of blossom, gives them obvious interest from the standpoint of the amateur plant experimenter. It should be noted, also, that there are some salvias with white leaves, one of these having foliage so thoroughly covered with a white thick wool-like growth that the leaves make excellent pen wipers. The experimenter who works with one of these varieties could doubtless develop interesting modifications of leaf through selection alone, and, of course, hybridizing methods could be utilized to accentuate the variation.

More Japanese Visitors

These flowers suggest the range of variation in form and contour and color among seedlings of the Japanese iris. Many of the variants are beautiful, and some are grotesque, and all of them are highly interesting from the standpoint of the plant developer.

A plant that is exceptionally interesting because of the work that has been done with it in recent years is the familiar evening primrose (*Oenothera*).

Mention has been made in another place of the famous work of Professor DeVries, which furnishes the foundation for his celebrated theory of mutation. It will be recalled that Professor DeVries found specimens of evening primrose that departed so widely from the form of their parent as to seem to constitute new species. The question whether these mutations were of unexplained origin, or whether they were really due to hybridization, is still perhaps an open one. But, in any event, the use made of them by Professor DeVries called particular attention to this plant, and has given it a place quite apart among flowers of field and garden.

There are many species of evening primrose, and the tendency to vary among them is marked. Variation, however, does not extend to the flower. There may be all manner of modifications of stem and leaf, but the typical blossoms of the evening primrose are of a pleasing pale lemon yellow.

My Primrose Experiments

I have experimented with the primroses, crossing them quite extensively. One form that was received from the mountains of Chile has given

Unnamed Flowers from China

Here are blossoms of an unknown species of flower, obviously closely related to the iris, the bulb of which was sent to Mr. Burbank from China. The gardens at Santa Rosa teem with nameless exotics, all of which are sure to be tested as to their propensities and capacities.

some interesting results through selection, in that it now produces blossoms, a single petal of which would cover the entire blossom of any of tne larger primroses under cultivation. The flower itself is sometimes six inches or more in diameter. A bed of these plants reminds one of a lot of handkerchiefs spread out on a lawn, as the blossoms are somewhat square with rounded corners. A new crop is produced each morning throughout the entire summer.

The plant itself is somewhat trailing, and about two feet to two and one-half feet in diameter. It is a perennial, though it commences to bloom quite early in the season.

This large flowered variety has been produced by most rigid selection for size, form, and whiteness and substance of flower, and it far surpasses all other members of the genus in size and beauty.

I have hybridized this Chilean race with the common *Oenothera acaulis,* or *Taraxacifolia,* and produced a large number of intermediates, from the best of which I have made selection. These hybrids seem to come absolutely true in the second generation, so far as foliage is concerned, being in all cases intermediate between the two species. This is perhaps what would have been expected in a member of this race, in view of the observations of Professor DeVries. The plant

Selected Chinese Iris

Note how widely this flower differs in form and general appearance from the iris shown in earlier pictures. Such variations are always a source of gratification to Mr. Burbank, as they furnish obvious material for crossbreeding experiments. Interesting tests of the present flower have been made in that connection.

seems to have an exceptional propensity to form new types.

This, of course, is precisely the characteristic that gives the plant interest from the standpoint of the amateur experimenter. So a plot may very well be set aside in the flower garden for some evening primroses of two or three species. Hybridization will readily be effected by the insects, if the experimenter does not care to take the trouble to hand-pollenize the plants, and the production of some interesting new forms may fairly be counted on.

I will name only two other common plants from among the almost numberless ones that might be selected, as offering advantageous material for selection by the amateur experimenter. But these are about the commonest of all, and in some respects among the most beautiful and interesting—the golden rod, and the aster. These plants are almost universally associated when growing wild in the field, and their blossoms form so beautiful a contrast that the two may very well be transplanted to the garden together.

I have experimented quite extensively with the goldenrods, and at the same time made a collection of the native asters. And while the two plants are so very different, the fact that they blossom together late in the fall and harmonize so beau-

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An Improved Evening Primrose

Mr. Burbank has worked extensively with the evening primrose. This one is a species from South America, which attains altogether unusual dimensions, some specimens suggesting a small handkerchief spread out on the foliage. Mr. Burbank's experiments with the evening primrose have convinced him that Professor DeVries' celebrated mutants of this tribe are in reality hybrid forms.

tifully in the landscape, makes it worth while, as I have just suggested, to work on the two in combination.

The golden rods are of so many species and so variable that they tax the skill of the botanist. To differentiate between them accurately is a task lying far beyond the skill of most amateurs. But for that matter, it is my observation that the different species hybridize so freely when growing wild that the specific lines are thoroughly broken down.

Any botanist who pretends to fix hard and fast lines between the different species of golden rods, and does not take account of the hybrids, which are even more numerous in many localities than the parent forms, will not gain a very adequate idea of the golden rods as they actually grow.

Any species of golden rod will serve the purpose of the experimenter. But, of course, it is desirable to have a number of species, and it is obviously worth while to make careful selection in deciding which ones to transplant to your garden. I have spent many days on a few acres of ground, searching among the multitudes of golden rods for the most beautiful individual specimens. From these selected seed was collected, or the roots themselves dug, to furnish the basis for further experiment.

A Spray of Goldenrod

There are numerous species of goldenrod and these grow in neglected fields almost everywhere. Mr. Burbank found that the different species constantly hybridize in a state of nature. He suggests that the goldenrods are very interesting flowers for experiments by the amateur in crossbreeding and selection.

Some of the wild forms seem almost perfect, yet when taken under cultivation and carefully selected they prove susceptible of betterment.

The hybrids, in my experience, are not as variable as might be expected. But this is no doubt because the plants with which we worked were themselves hybrids. In point of fact, one can seldom be sure, in working with the golden rods, that one is working with pure species.

But such complications, of course, give added interest to the work of the plant developer after he has the fundamentals of the method fairly in hand. And I can think of few problems that would be more interesting than to attempt to untangle some of the hereditary complications among the golden rods. The fixing of types by selection; the improving of the best existing ones; and the development of new types by hybridization—these are all methods that offer opportunity for fascinating experiments.

Whoever takes the trouble to make friends of the golden rod is not likely to regret his experience.

—Any old-fashioned flower garden will furnish abundant material for all the experiments that any amateur need care to undertake.

The Tigridia and Some Interesting Hybrids

New Charms In Far Away Flowers

ABOUT a quarter of a century ago I commenced cultivating and crossing all the *Tigridias,* or Tiger Flowers that were then offered by any seedsman or nurseryman anywhere in the world.

I also secured all the species of the allied genus *Ferraria* that I could obtain and cultivated them for the purpose of hybridizing them with the tiger flowers. The Tigridias are natives of subtropical and tropical America, ranging from Mexico to Peru and Chile. The Ferrarias are from the Cape of Good Hope, and are represented by a number of species.

Both tribes belong to the Iris family, and the two forms are so closely related that by some botanists they are regarded as properly falling within the same genus.

My own experiments, which show the ready

hybridization of the various Tigridias and Ferrarias, suggest that they are closely related. Yet the fact that they are indigenous to different continents shows that they have been separated for a very long period of time, although doubtless of common ancestry.

The students of geological botany tell us that there must have been a great mass of land in the southern hemisphere at one time on which races of plants developed that subsequently were isolated on the land masses that are now known respectively as South America, Africa, Australasia, and New Zealand. At that remote period the Tigridias and Ferrarias were doubtless of one stock, and the fact that their descendants of to-day retain such elements of affinity as to puzzle the botanists and to serve well the purposes of the hybridizer gives another illustration of the wonderful pertinacity with which the characteristics of a plant are sometimes transmitted through almost numberless generations without radical transformation.

It is little wonder that the earlier biologists, before the coming of Darwin, when confronted with such observed cases of affinity between races that must have been separated for countless thousands of years, were strong in their faith in the fixity of species.

The Interesting Tigridia

The tigridias are very interesting lily-like flowers from the tropics. Mr. Burbank has experimented with them very extensively, both by way of selection and through crossbreeding. Some of the results of these experiments are shown in succeeding pictures.

Yet the facts of variation, even within a few generations, are too obvious to escape attention.

And the compromise has been found, as everyone knows nowadays, in a recognition of the fact that time is long, and the further fact that natural selection may be instrumental in maintaining the fixity of a race, provided the environing conditions are unchanged, just as it may be instrumental in somewhat rapidly changing the form of a race when the environing conditions have altered.

Hybridizing the Tiger Flowers

From the outset I found that the various tiger flowers throve in my gardens, particularly in the sandy land at Sebastopol and in sandy beds especially prepared for them at Santa Rosa.

As I have already said, I began at once crossing and hybridizing the various species and varieties, and of course carried out selection among the seedlings and made new crossings, according to my usual custom. The type species with which the experiments began was the *Tigridia pavonia,* of which there are numerous varieties. Another form known as the *Conchiflor* or Shell flower was utilized, and subsequently the *T. buccifera,* a form more recently introduced from Mexico.

An especial effort was made to introduce also into the combination the strains of a plant of yet another genus, the *Herbertia platensis.* This is a

tall-growing plant bearing close resemblance to the Tigridias, and by some botanists classified with them. It has pale blue flowers marked with yellow, and the specimens are of a somewhat different structure from those of the Tigridia, though the bulb and general growth of the plant are similar.

I particularly desired to introduce strains of the *Herbertia platensis,* because this is a very strong-growing plant, and its vigor and health would be of great service in giving hardiness which is the one thing that the Tigridias more especially lack.

In particular, the bulbs of the tiger plant are difficult to keep over winter, and especially subject to decay from exposure to air and to the attacks of aphids when stored.

But much to my disappointment I was never able to effect hybridization between any of the Tigridias, either pure bred or hybrid, and the Herbertia. The experiment was made over and over, and in every case it was without result.

Meantime, however, there was no difficulty whatever in hybridizing the ordinary cultivated strains of Tiger Flowers among themselves and with some of their South African relatives. And the results of such hybridizings were manifest almost from the outset.

One of the most striking modifications shown

Hybrid Tigridias

The word tigridia or tiger flower, would suggest a striped flower, whereas in point of fact this flower is spotted. Mr. Burbank suggests that the word "leopard" or "panther" would have been more appropriate; and that the term "jaguar flower" would have been still more significant, inasmuch as the tigridias come from South America, the home of the jaguar. The specimens here shown are hybrids of a very interesting type.

by the hybrid Tigridias was the development of varieties having striped flowers. It might very well be expected that a "tiger flower" would be striped. But in point of fact the native Tigridias are spotted and never striped. They might with much greater propriety have been named after the leopard or panther, or better yet, considering their origin, after the South American jaguar. But the botanist who originally named them seemingly had rather vague notions as to the markings of the coat of the tiger, or else considered it sufficient that the flower itself wears a yellow mantle with dark markings.

In any event, there is something about the aspect of the flower that makes the name "tiger flower" seem not inappropriate.

And the propriety of the name becomes quite beyond challenge when my new hybrid varieties are under observation. For these are striped in a way that is very striking. Quite aside from its suggestions as to one feline or another, however, the new hybrids are flowers of great beauty and interest and differ conspicuously from any of the parental forms.

Not only are the markings thus conspicuously altered, but the flower itself is greatly increased in size. The tendency to freedom of bloom is accentuated. Moreover the hybrid plants have

gained greatly in vigor of growth, in hardiness, and in resistance to disease.

The colors of the new flowers are conspicuously brightened. The striping is usually crimson on white, crimson on yellow, or yellow on crimson. In addition to presenting these stripes, which are quite unlike any marking of the native Tigridias, the hybrid flowers generally retain the dotting at the center that characterizes the tribe in its original form. But these dottings are greatly increased in size. In some instances, on the other hand, the dottings are partially or entirely eliminated.

The original types of these very striking new forms of Tiger Flower were readily fixed so that they breed absolutely true from the seed.

It was possible, however, to increase the size of the flower by selection, and this increase in size was a permanent acquisition; also to add brilliance with new combinations of colors.

And of course the hybrid plants thus perfected exceed greatly the size of any plants that could have been developed by mere selection without crossing.

Utility as Well as Beauty

The new tiger plants, although still lacking something of hardiness, were greatly improved in this regard over their ancestors.

Most of the old tigridias, as I have said, are

Another Hybrid Tigridia

None of the tiger flowers are striped, which seems to make their name inappropriate, as already suggested; nevertheless there does seem to be something tiger-like about this richly caparisoned and oriental-seeming flower. It is rather curious to reflect that the spots on the flower are intended to make it conspicuous, whereas the striped coat of its namesake is calculated to make the animal invisible in the jungle.

quite subject to insects and disease. The hybrid forms are much more resistant. There is also a greater power on the part of the new plants to stand sunshine. The old tigridias sometimes withered under the influence of the sun. This might not at first thought be expected of a tropical plant, but it should be recalled that the growth of vegetation in tropical regions is so luxuriant that low-growing plants of this order are not usually subject to the direct rays of the sun throughout the day.

It goes without saying that the bulbs of the new tiger plants were improved in proportion to the stalks and flowers. The bulbs of the tiger plant are elongated and tunicated, and multiply by division somewhat after the manner of the hyacinths, tulips, and the allied races in general.

The bulbs of the new hybrid tigridias were doubled in bulk, and in some cases quadrupled, as contrasted with the parent forms. Like the somewhat similar bulbs of the gladiolus, they may best be kept in the ground over winter here in California, instead of being taken up and stored as is necessary in colder climates.

The development of the bulbs of the tigridias has not been at all a matter of accident. At all stages of the experiment in hybridizing and selection, I have paid the most careful attention to the

Variant Hybrids

It will be seen that the different tigridias hold rather closely to the same characteristic type of flower. There is, nevertheless, a good range of variation as to size, precise contour of petals, and color. Of course the hybrids show combinations of characters that are not united in any single one of their parents. There is the usual tendency to the segregation of these characters into many new groups in the second generation.

condition of the bulbs, selecting always those that were largest, firmest and soundest. And the reason for this was not merely that such bulbs usually produce the best flowers, but also that it is worth while to improve the size and quality of the bulbs quite on their own account.

The particular reason for this is that the bulbs of the Tiger Plant are edible. When cooked like potatoes, or made into a stew, they constitute a really delicious vegetable.

To my taste the bulb of the tiger plant is at least the equal of any vegetable under cultivation. It is also highly nutritious. I am not sure that it has an equal among the vegetables of our gardens in its combination of nutritiousness and appetizing flavor.

These very qualities lead to its destruction by all kinds of animal and insect life, like the *Lilium Brownii,* which has no bitter principle, containing sweet and nutritious matter, and which also is attacked and appropriated by insects and other creatures.

As yet the tigridia is too tender to gain a place in the vegetable garden on a footing with the potato and allied bearers of bulbs and tubers. But when through further breeding experiments, it has been rendered more amenable to general cultivation, its bulb being at the same time still further

Seedling Tigridias

The wild species of tigridias of course breed true from the seed. But, equally of course, the hybrid forms cannot be expected to do so. So there are fascinating possibilities of variation among the progeny of any hybrid. Yet even the most widely varying specimen is at once recognizable as a tigridia.

increased in size, the tiger plant may come to be valued for its edible bulb quite as highly as for its beautiful and spectacular flower.

Multiplication by Bulb Division

The habit of storing nutritious matter in its bulb, and the further habit of producing collateral bulbs from which new stalks will grow, so that the plant multiplies indefinitely in this way, is characteristic, as everyone knows, of a large number of plant families, many of which have come within the scope of our studies.

The phenomenon of bulb division, indeed, is so familiar to everyone who has experimented in the vegetable or flower garden as to take its place among those familiar matters of fact that call for no comment.

Yet if we consider the matter thoughtfully it will be clear that this habit of putting forth offsets from a bulb as the basis for the development of new plants is an altogether extraordinary phenomenon—quite as mysterious, indeed, as the production of the seeds that bear the complex hereditary factors and transmit the qualities of a race of plants from one generation to another.

There is, in point of fact, no fundamental difference between the production of new plants by bulb division and their production by seed, except that in the latter case there is opportunity for the

union of two different racial strains, one borne by the pollen and the other by the ovule. This, to be sure, is a difference that has very important practical bearings, inasmuch as the union of two different hereditary strains gives opportunity for the blending of hereditary factors and their re-combination, thus compelling variations that furnish the basis for natural or artificial selection, through which new races are developed.

All this needs no explication here, as our earlier studies have made it perfectly familiar. But what I wish now to emphasize is the fact that the bulb that produces a new plant carries the hereditary factors of the parent plant substantially as they are borne by the ovule or the pollen grain that the same plant puts forth on its aerial stalks, and exactly as the bulb of any plant—in fact, the bulb of any plant is only a fat, immature, underground bud.

If the ovule could develop without being fertilized, or if the pollen could grow into a plant, the result in either case, we may reasonably assume, would be a reproduction of the plant closely similar to the parent form, just as the aphids and the bees when parthonogenetically produced, and in a few instances of plants, for example, the violet. Yet there are differences between the different pollen grains and between

Another Bunch of Seedlings

These hybrid seedling tigridias exhibit yet another type of variation; yet, like the others shown, they are manifestly tigridias and nothing else. The flower has not yet been long enough under cultivation to take on those wide departures of form and color that characterize many of our cultivated plants. For this very reason, the tigridia holds possibilities of development that should appeal to the amateur.

the different ovules of the same plant, as demonstrated by the fact that flowers, for example, of different hues may be borne on plants grown from a single seed pod.

So if we are to present the matter quite in its true light we should say that the *aggregate* pollen-product and ovule-product of a plant must be considered as representing the personality—that is to say, the hereditary complex—of the plant.

No single pollen grain and no single ovule contains representatives of all the types of hereditary factors that are present in the germ plasm of the plant as a whole.

Stated otherwise, the pollen grains and ovules are very specialized and concentrated portions of matter, each of which contains a similar equipment of the *most fundamental* of the hereditary factors, but each of which contains a somewhat different assortment of the *less fundamental* ones.

All the plants that grow from the seed of a tigridia, for example, will be unequivocally tigridias in stem and leaf. But there will be minor differences among them as to details of size, as to freedom of flowering, as to precise size of flower, and as to the exact distribution of the color markings.

As a matter of course, when the seeds are the product of cross-pollenizing, the offspring, repre-

Bulbs of the Tigridia

This large tigridia bulb is developing a cluster of small offshoots. Each of these little bulbs will produce a plant duplicating almost absolutely the original parent form. There is no such range of variation among plants grown from bulbs as among those grown from seeds. The bulb of the tigridia has exceptional interest because it is edible.

senting now two parents, will show a still wider diversity of hereditary traits.

Meantime, turning attention again to our bulb, we find that this structure represents the parent form with much greater fidelity. As nearly as there can be identity between two different living things, the plant that grows from any offset of the bulb of any given Tigridia will be identical with the parent form.

A certain amount of diversity there must always be, because no two living organisms are absolutely identical.

But for all practical purposes it may be said that the different plants grown from offshoots of an original bulb are identical. The process of bulb division can be repeated a thousand or a million times, until the original bulb has been so multiplied that its descendants people the earth. But from first to last, one bulb will be substantially like another, and all the myriads of plants that have thus arisen may be said to constitute a single personality.

All this is such familiar matter of fact as to excite no comment.

Yet, rightly considered, it is a fact of the most mystifying kind and one that must excite wonderment on the part of anyone who gives it serious consideration.

That the multitudes of hereditary factors that exist in the germ plasm of so complex an organism as a flowering plant should be grouped in each successive bulb that develops as an offshoot of the original bulb of that plant in precisely the same combination, pre-determining the production of a future plant identical with the original, is a fact that becomes increasingly mysterious the more carefully we consider it.

In particular, the mystery is great if we have kept in touch with modern ideas as to the segregation of the germ plasm and the body plasm of the living organism. There is a current notion, supported by high scientific authority, that the very earliest division of a fertilized egg cell, in the case of an animal or plant, results in the separation of the infinitesimal fleck of protoplasm into two different parts that are fundamentally different, one carrying the body plasm from which the structure of the new individual is to grow, and the other carrying the germ plasm that is to convey the potentialities of future offspring.

New studies in the biological laboratory have shown that this idea, that the first division of the egg cell results in such a segregation of body plasm and germ plasm, cannot be fully accepted. Nevertheless it is obvious that in the case of all higher organisms, whether vegetable or animal,

A Blue Tigridia

Here is a Burbank hybrid tigridia that has taken on a color variation that is very striking. It is a complex hybrid, further developed by careful selection in Mr. Burbank's garden. It represents the result of one of his most interesting series of experiments in breeding the tigridias.

the germ plasm may be a thing apart. As finally segregated, for example, in the ovules and pollen grains, it constitutes a concentrated aggregate that transmits the hereditary factors from generation to generation in a sense independently of the bodily characteristics of the individual plant.

You may, for example, determine that a given flower and the seed that grows from it shall be of exceptional size and vigor by cutting off all other flowers so that the energy of the plant shall be concentrated on a single one. But in so doing you merely give added vigor to the new generation; you do not alter its fundamental hereditary characters. These are pre-determined by the factors in the germ plasm that have been brought from earlier generations and of which the individual plant is only the carrier.

All this, then, suggests the isolation of the germ plasm; and the newest theories of heredity have tended to emphasize the idea that germ plasm and body plasm are things of a somewhat different order.

Yet the phenomena of reproduction by root division or by the putting out of new bulbs, furnish a striking demonstration that the germ plasm which predetermines the form of the future plant is present not alone in the pollen grain and the ovule, but also in the bulb.

Even from the single bud of a bulb, as we have seen illustrated in several cases, a new plant will grow that will duplicate absolutely—in the interpretation just given—the qualities of the parent plant. And when we were studying the fruit trees we saw that the same thing is true of any aerial bulb if grown even on a foreign branch.

Root bulb and aerial bulb alike contain the essential germ plasm of the individual of which they are a part. They nurture potentialities of a new individual that will duplicate the parent form.

Germ Plasm and Body Plasm

From all of which it follows that the germ plasm of the plant cannot be thought of as isolated from the body plasm. It may well enough be segregated within the substances of any given cell. But that it is present in connection with the living cells of the plant everywhere, from its roots to its remotest stem, is clearly demonstrated by the every-day methods of propagation employed in orchard and garden.

Such being the case, it is difficult to avoid the conviction that the germ plasm that is part and parcel of every cell of the body plasm of the entire plant is more or less subject to the environing influences that effect the body of the plant. And from this it would follow, at least as a reasonable inference, that environing influences that modify

Tigridia Seeds at Wholesale

This sail cloth full of tigridia seeds gives a striking illustration of quantity production in Mr. Burbank's gardens. Sometimes, as we have seen, only a very few flowers are selected among thousands, to continue an experiment. But here the experiment with the tigridias is at a different stage, and large numbers of seeds are selected, to give opportunity for immense beds of variants the coming season, among which selection will be carried out more rigidly.

the structure of the plant body must have an effect in modifying also the germ plasm in a way to influence the character of the future plant that develops from that germ plasm.

And as much as this, it should be added, is admitted by all experimenters, even by those who deny the possibility of the transmission of acquired traits in the older interpretation of that phrase. That altered conditions of nutrition may modify the condition of the germ plasm in such a way as to modify the state of the offspring has been shown by experiments in many fields, both with animals and vegetables. Such being the case, the question of the transmissibility of acquired traits is reduced, as I have elsewhere quoted an authority as saying, to a matter of definition.

Nevertheless, for practical purposes, it is unquestionably true that the germ plasm is enormously difficult to influence, and that under all ordinary circumstances it will convey its hereditary factors unchanged, or not appreciably changed, from one generation to another. In attempting to modify the forms of successive generations, the method that has hitherto proved successful, has been, not the modification of the individual germ plasm, but the bringing together of different germ plasms from diverse organisms through hybridization.

For such union of germ plasms there is obviously no opportunity in the case of the new plant grown from the bulb.

Hence the fixity of type of plants propagated in this way—a fixity that is often of the utmost practical importance, as in the propagation of a new race of vegetables or flowers, but which, by the same token, puts the plant thus propagated outside the field of the plant experimenter.

Complementary Modes of Propagation

Thus the two methods of propagation that are available for such a plant as the tigridia and for countless others of its ilk, are in a sense antagonistic or complementary in their influence on the history of the plant itself.

Propagation by bulbs insures spread of the race, but insures also maintenance of the racial fixity.

Should environing conditions change, it is unlikely that plants thus propagated could change rapidly enough to adapt themselves to these conditions.

But at the same time that the plant is producing new bulbs it may also, year by year, produce seeds that are the result of cross-fertilization. And this method of propagation is a perpetual bid for such variation as will make possible a relatively rapid change in adaptation to a changing environment.

A Nameless Missionary Flower

This odd flower was grown from seeds sent Mr. Burbank by a missionary from China. Many interesting results have been obtained at Santa Rosa by experimenting with flowers sent by missionaries. In this case, the similarity to the tigridias suggests the possibility of hybridizing experiments, which, however, have not as yet been undertaken.

That vast tribes of plants should have found it necessary to adopt both methods of propagation is in itself an evidence of the struggle for existence that is the basis of natural selection.

In another way, also, the bulb perhaps evidences the hardness of the struggle for existence, particularly in tropical climates. Everyone knows that vegetation is exceedingly luxuriant in the tropics, and it is a matter of observation that the habit of developing tubers and bulbs is especially common among the herbaceous plants of tropical and sub-tropical regions. Perhaps one explanation is that the storing of food-supplies in the bulb enables the young plants to shoot up rapidly without waiting for the development of a large root system.

By so doing they may stand a chance of competing with the surrounding vegetation and thus have a far better chance of reaching maturity than if they had grown from tiny seeds.

It is probable, therefore, that the generality of bulbous plants that one would find in any given locality in their native haunts would have developed as offshoots of the bulb of an original plant or as inbred or close-bred. So the bulb has very fundamental importance in the plant economy. And it is interesting to reflect that it is correspondingly important from a human standpoint, inas-

much as bulbs furnish us some of our most important food products.

We have seen that a good many of the plants that are propagated solely from the bulb or tuber, of which the potato is the most familiar example, may give up the habit of seed production altogether under cultivation. But, on the other hand, it is observed that plants that produce comparatively small bulbs in the state of nature may be stimulated to the production of far larger bulbs and more abundant offshoots under cultivation. And the inherent reason for this is obvious when we consider the share the bulb must play in perpetuating a species and aiding it in the struggle for existence under widely varying conditions and in competition with other plants.

Making application to the particular case of the tigridia, it has already been recorded that I have found no difficulty in doubling or even quadrupling the bulk of the bulb of that plant, as well as greatly increasing the tendency to the multiplication of bulbs.

I repeat that it will probably be found desirable to cultivate the plant further along these lines until it finds recognized place in the vegetable garden as the producer of a food of the finest quality, while at the same time retaining value as the bearer of beautiful flowers.

Burbank Hybrid Verbenas

The reader is aware that Mr. Burbank takes the greatest possible interest in common flowers, no less than rare ones. His experiments with the verbena, for example, have been carried out on a large scale. Here are some hybrids showing a wonderful range of color variations.

Four
Common Dooryard Flowers and Their Improvement

Work on the Verbena, the Pink, the Petunia, and the Geranium

MY most interesting verbena was the one named the Mayflower. I use the past tense because I am not sure that any representative of the variety named Mayflower is now in existence. I have introduced the plant through a prominent horticulturist, but he apparently found it difficult to reproduce it with sufficient rapidity from cuttings and so attempted to propagate it more rapidly from seed.

Unfortunately the verbenas are so mixed a tribe, and the various races so little fixed, that they do not breed true from the seed. And so when I myself sent to the horticulturist for a sample of the fragrant Mayflower verbena a few years later, I received a plant that had but a reminiscence of the distinguishing quality of the original.

In the meantime, however, I had developed

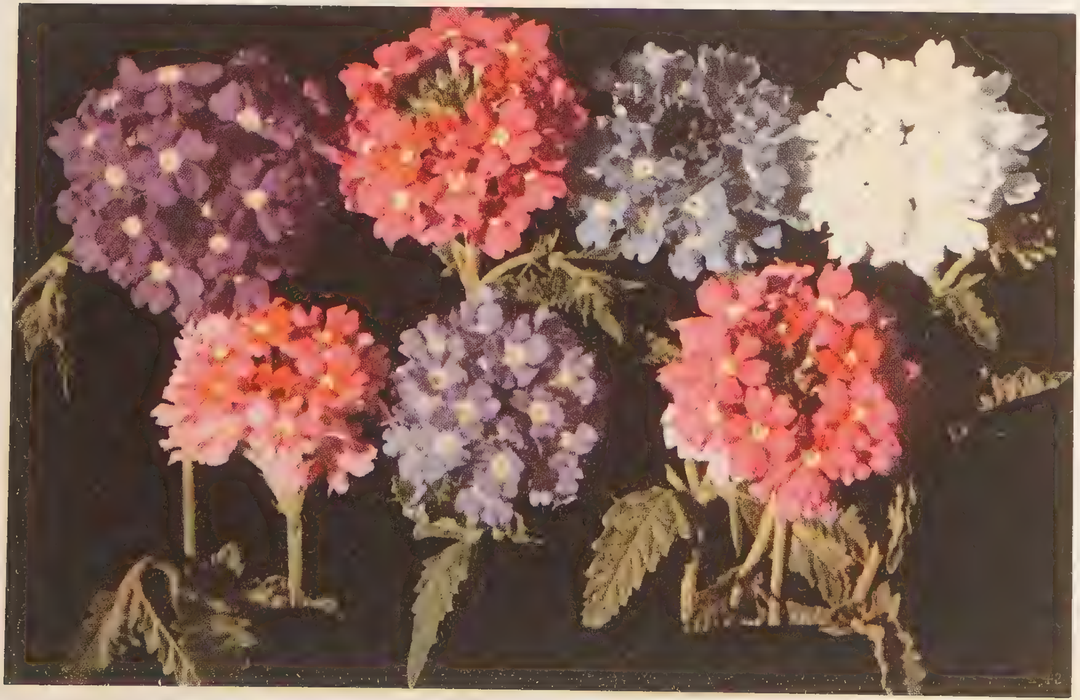
another race of fragrant verbenas, which was introduced in 1901 under the name of Elegance verbena. These are the two stocks from which a large number, at any rate, of the fragrant verbenas now under cultivation have been developed.

My first fragrant verbena, the Mayflower, was developed after I had worked for many years with this flower and had grown great quantities of the seed for distribution. The plant from which the fragrant race was developed was found among many thousands, most of which, as is usual with the cultivated varieties, have a rather disagreeable odor.

I had noticed, however, that there were members of the verbena colony that had a very slight fragrance, especially in the evening. So I began a careful search among them to find a plant the flowers of which had the most pronounced perfume.

After a long search among the thousands, I found at last a plant that was distinctly fragrant, markedly surpassing in this regard any of its associates.

This individual was of course carefully isolated and its seeds were gathered. In due course I had a number of seedlings among which some were found that produced flowers more fragrant than those of the parent. The selection was con-



More Burbank Hybrid Verbenas

Note the wide range of variation among these hybrid verbenas. Observe also that the centers, in some cases, have been filled up and made solid. The verbena is a plant with which any amateur may readily work, and this picture suggests interesting possibilities of developing new varieties.

tinued, according to my usual method, through successive generations, until at last a plant was found that is as fragrant as could be wished. The plant in question was an exceedingly large verbena—in fact one of the largest ever grown. The flowers it bore were of a rich rosy pink in color, the exact counterpart of the color of the familiar trailing arbutus or any flower of New England.

Curiously enough the fragrance of the new verbena was also precisely that of the arbutus in quality, although it was much more intense, as was readily admitted by all who tested the two flowers side by side.

It was for this reason that the new verbena was given the name of Mayflower.

Several perfumers who saw this verbena were agreed that it would be of value for the production of a perfume. It was admitted by all that no verbena with a comparable odor had ever before been seen.

The subsequent history of the Mayflower has already been told. It was purchased by a dealer, and although plants grown from cuttings made from it are probably in existence, I do not know where they are and do not know how to trace them.

Aside from its fragrance, the Mayflower was an interesting type of verbena, owing to its size

and prolific bearing and the beauty of its flower. But seedlings grown from the plant could not be depended upon to produce flowers that would reproduce the Mayflower odor. Indeed they could not be depended on to reproduce any particular characteristic of the parent plant.

In point of fact, seedlings of the Mayflower produced plants bearing blossoms of almost every color—scarlet, crimson, almost pure white, yellow, deep cobalt blue, purplish. But not one of the many thousands I raised afterwards had the delightful flavor of the Mayflower.

The Mayflower Accounted For

As might be inferred from its variability, the fragrant verbena was a very mixed hybrid. It was the outcome of hybridizing experiments in which I had utilized the various races of the plant under cultivation. I had not only grown and crossed the ones that are in the seed catalogs, but also secured seeds from all four of the original species from which the cultivated verbenas have been developed, collected from wild plants in South America.

It is quite unnecessary, however, to hybridize the verbenas in order to secure variation, as all of those that are under cultivation are themselves hybrids of very mixed strain, and the plant has been cultivated for a comparatively short period

A Burbank Fragrant Verbena

Mr. Burbank takes particular delight in developing obscure qualities of flowers. He has developed fragrant varieties of a good many flowers that are ordinarily odorless, as the reader is aware. His success in this regard with the verbena has been very striking; a number of his fragrant verbenas having been introduced, and widely cultivated.

and none of the familiar forms breed true from the seed.

The ancestors of the cultivated verbena were South American plants, and it is believed that there are four chief species that have been variously hybridized to produce all the forms now under cultivation. One of these bears flowers of brilliant red, two others have flowers that are rosy or purple in color, and the flowers of the fourth are pure white.

The hybridized races show the breaking up of these colors, quite as might be expected, with the presentation of all the primary colors in many of their hues and gradations, although pure blues are not well represented, and pure yellow is very exceptional.

But the point of greatest interest in the present connection is the fact that the white species of wild verbena, which is acknowledged to be one of the forms, whose strains have been blended with the others to produce the cultivated verbena, has what is described as a rich jessamine fragrance.

The hybridizing experiments that ultimately gave us the perfected verbena were carried out less than a century ago, but in the meantime the strains have been so mixed and blended that it would be impossible for the most part to trace the characteristics of any given form of cultivated ver-

bena with certainty. But it is obvious that the hybridizers and those who further developed the plant by selection were chiefly influenced by form and color, as has been the case with so many other flowers, and paid little attention to the question of fragrance.

The verbena has been made to develop wonderfully symmetrical clusters, and its flowers have taken on the most gaudy hues. But in the main, as already pointed out, the odor even of the most beautiful specimens is disagreeable rather than attractive.

Yet one of the wild parents, as we have just noted, was fragrant; and our previous studies of heredity give us full assurance that the factors for fragrance must be retained in some at least of the hybrid progeny, and will now and again make themselves manifest. That such is really the case, my fragrant verbena clearly enough demonstrates. To be sure its fragrance is not just that of the original. Some slight chemical modifications have taken place, doubtless through the blending of other chemicals that represent the odoriferous qualities of the other species, and it is only by rare exception that an individual appears having just the right combination to produce an attractive perfume.

But the point of interest is that when such an

A Bed of Burbank Verbenas

Here we see another illustration of quantity production, with a characteristically wide range of variation, giving Mr. Burbank the opportunity for selection which he so highly prizes. Obviously here is material for the development of almost any number of varieties of ***verbena.***

individual does appear, as in the case of the Mayflower and the later form named the Elegance, the anomaly is accounted for quite adequately by a knowledge of the existence of fragrant species among the ancestors of the hybrid.

Even if we had no knowledge of the existence of such an ancestor, we should still be justified in assuming that a fragrant verbena is really a case of atavism. It will be recalled that we invoked the existence of remote unknown fragrant ancestors in explanation of the appearance of our fragrant calla. But there is an element of added interest in the knowledge that in the case of the verbena the ancestor responsible for the quality of fragrance can be traced.

It would constitute a very interesting experiment in heredity, should someone care to undertake to hybridize a fragrant verbena with an odorless one and to trace carefully the hereditary influence of this quality—noting, for example, whether it acts as a prepotent or as a recessive character, and whether it tends to reappear in the second generation in any fixed proportion of the progeny.

It will probably be found that the condition that leads to the production of perfume of a particular type is so complex and itself dependent upon so many factors that it is not inherited in any simple and readily traceable relation.

One of the distant relatives of the fragrant verbena is a fine shrub, worthy of introduction, known as the *Alovsia citriodora.* Another, as different as possible in appearance, is a little trailing plant known as *Lippia repens.*

This little trailing plant is very valuable as a substitute for lawn grass. It requires less than one tenth the water required by blue grass, and only a fraction of the care. It need be sown only once or twice in a season, and throughout the summer it will cover the lawn with a dense foliage, and bear a mass of small blossoms resembling those of white clover and fully as attractive to the bees.

Unfortunately the lippia is not very hardy, and when the temperature goes much below freezing it turns to a disagreeable brownish color. Thus it is not adapted to the cold climates of the Northern United States.

If it could be given hardiness through selection and cultivation, it would prove a very important acquisition for the making of lawns that will withstand the summer drought.

An allied species is the moss-like *Verbena erimoides,* which is an exceedingly pretty plant growing wild in the high Chilean mountains. In California it produces seed so abundantly and hence multiplies so rapidly that it becomes almost a

Some Burbank Petunias

The petunia is another very common flower with which any amateur may work. Mr. Burbank has experimented with many varieties, and has produced some interesting forms, of which sample specimens are here shown. Compare these with the variants shown in other pictures.

weed. It is possible that new and interesting varieties of verbena may be produced by hybridizing the familiar cultivated ones with some of the wild species that have not hitherto been brought into the combination.

Carnations, or Pinks

It is rather anomalous that a plant should bear at the same time two popular names suggestive of colors so different as pink and carnation and the anomaly is not lessened by the fact that the plant itself bears flowers not only of the colors suggested but also of the purest white. Such, however, is the case with the plants that are known to the botanist as constituting the genus Dianthus.

Despite the paradox, however, the Dianthus fully justifies its popular names, for specimens are of the most vivid carnation and others are of the most beautiful pink. Meantime the white ones are as beautiful in their way as either of their more gaudy sisters.

Our studies of other flowers have made it seem commonplace enough that a plant should show such diversity. But the carnation as represented by one of my hybrid varieties, presents a color anomaly that has not been shown by any other flower with which we have made acquaintance; nor, indeed, so far as I am aware, by any other flower whatever.

The anomalous plant in question is one that produces flowers that are snow white in the morning when they first open, yet which at noon are bright pink, and which, finally, toward evening assume a deep crimson color. Each flower goes through this process during the first day, but sometimes the changes in color take place a little more gradually; so that each morning one may see on the same plant carnations that are crimson, a few that are pink, and freshly opened ones of white, giving the plant a very striking and unique appearance.

It chances that the plant that bears this curious flower is a most astonishing bloomer, seeming indeed to have more blossoms than foliage. So its tri-color display is indeed a striking one.

The plant that bears these anomalous flowers is the hybrid offspring of a white carnation and of the deep crimson one known as *Dianthus Chinensis.*

The plant itself is about eight or ten inches high and of quite compact growth, in these regards pretty closely resembling the Chinese parent. The foliage appears to be about an even combination of the characters of the parents. The flowers, as we have seen, combine the traits of the blossoms of the parent forms in a very anomalous way. Our earlier studies would lead us to expect that the

More Burbank Petunias

The fringed petals of these Burbank petunias are especially attractive. Mr. Burbank has an eye always to artistic qualities in making selections among his plant proteges. The petunias have proved very apt pupils.

combination of a crimson flower with a white one might produce crimson or white or pink. It would not surprise us to find hybrid plants of the same fraternity some of which bore the crimson flowers of one parent, others the white flowers of the other parent, and yet others pink flowers representing a blending of the two colors.

This indeed would be perhaps what we would expect of such hybrids, if not in the first generation then in the succeeding generations. But that the color factors should be so blended that each in turn should be dominant in the same individual flower, the transition from one to the other being marked by the appearance of an intermediate color, is an anomaly for which our studies of color hereditary have supplied no analogy.

We have considered it strange enough that different colors should be arranged in stripes on a flower as in the case of the four o'clock or in the new hybrid tiger flowers. But the carnation that is white at first and then pink and then crimson seems to suggest an even more curious compromise among conflicting hereditary factors. It evidences anew the curious flexibility of color schemes as applied to the petals of flowers, and presents the evidence from an altogether new angle.

It may be of interest to recall, in connection

with this curious manifestation of color heredity, that the carnation has been under cultivation from an early historical period. The name Dianthus, signifying divine power, is said to have been given it by Theoprastus three hundred years before Christ.

The flesh color of the original carnation was broken up into red and white more than three centuries ago. Since then multitudes of varieties have been developed. Yet there is a strong propensity in this flower to hold to uniformity of color as regards any individual flower. That is to say, carnations in general are likely to be uniformly scarlet or uniformly pink or uniformly white. There are variegated forms, to be sure, but these are exceptional.

This tendency of the flower to hold to one color or another may at least be recalled with interest in connection with the curious propensity of the tri-colored hybrid to give recognition to the different colors of its parents in the same flower in successive periods of time.

But however the anomaly may be explained, the tri-colored carnation was an interesting flower, whether considered from the standpoint of the horticulturist or from that of a student of hereditary.

I have produced no other variant of corre-

Large, Graceful, and Artistic

These Burbank petunias represent the result of some generations of careful selection, with an eye to the accentuation of all the traits that make the ***petunia*** *attractive.* ***There is*** *no reason to suppose,* ***however,*** *that the* ***limits*** *of variation have been reached in the specimens here shown.*

sponding interest in this tribe, although I have had twenty-five or thirty species of Dianthus growing for the purpose of crossing, and have produced some other variants of minor importance.

In general, it may be said that the carnation, having been worked on by plant experimenters for two thousand years or more, presents a difficult problem for anyone who strives to develop new races of unusual value. It is like working against the traditions of the ages to attempt to modify the characteristics of such a plant in a new direction.

The Petunia

The experiment in which I hybridized the petunia with the tobacco plant, producing the amonaly that was described facetiously as "the petunia with the tobacco habit," will be recalled as having been described in an earlier chapter.

Doubtless this experiment constituted my most interesting work with the petunia, although I have cultivated it largely and have attempted to cross it with other species, notably with the allied plant known as *Salpiglosis*. This plant is regarded by botanists as very close to the petunia, but I have been unable to effect a cross hybridization.

It will be recalled, however, that I hybridized the petunia and the tobacco with difficulty, and it is possible that a more extended series of experiments might result in hybridizing more satisfac-

torily with *Salpiglosis,* for the plants are botanically related pretty closely.

An illustration of what can be accomplished by an amateur who devotes attention to a single plant is given by the work of Mrs. Sheppard, of Ventura, California, and her neighbor, Mrs. Gould. The former took up the cultivation of flowers for the healthful outdoor life on the recommendation of her physician, and the latter became interested in the work through observation of the results achieved by her neighbor.

On the advice of Mrs. Sheppard, Mrs. Gould took up the cultivation of the petunia as a specialty. The result has been that some of the finest strains of petunias that are known have been sent out from California. One of the largest and best of these is the form known as the Ruffled Giant.

A great amount of time and skill are required in raising the best petunia seed, and there is still opportunity for improvement. It is particularly necessary to use good taste in the selection and combination of the colors. It is found to be, on the whole, easier to produce large flowers than those having a blending of clear, pleasing colors. There are a few common garden plants that give better opportunity for work of the amateur, particularly for one who has gained a certain amount of skill through previous experiment. The inter-

Chinese Pinks

The Chinese pink has obvious affinities with the familiar European varieties. Very likely the two are of common origin, but the Chinese flower shows the effects of its oriental environment, and good opportunities are afforded for the development of new varieties by crossing this flower with its European cousin.

esting character of the petunia tobacco hybrid will be recalled. Doubtless by sufficient persistency other hybrids having equal or even greater interest could be produced.

Geranium and Pelargonium

Several years ago I brought all the geraniums that I could obtain from European and American florists and collected also some fine specimens of a variety from British America. The last named variety is exceedingly hardy, growing as far north as Alberta, where the thermometer sometimes falls 60 degrees below zero in winter. I thought it would be of interest to hybridize such wild species as this with the cultivated varieties.

The pressure of other work, however, prevented me from carrying out the experiments on an expansive scale. I feel, however, that the experiment of crossing the wild and cultivated geraniums is well worth undertaking. The wild geranium is a much more promising plant to work upon, in my opinion, than was the original violet from which all our beautiful pansies have been developed. Indeed, there are few other plants among our wildlings that offer better opportunities for development.

My more recent work with the geraniums has had to do more especially with the form known as the Pelargonium, a plant that is horticulturally dis-

A Bed of Chinese Pinks at Santa Rosa

Here large numbers of the Chinese pinks have been allowed to run riot, that each plant might prove its capacities in competition with its fellows. Any morning now Mr. Burbank will go through this bed, and single out for marking, the half dozen or so plants that most fully meet his approval.

tinguished from the geraniums, but which is obviously closely related.

An interesting story is told of the way in which the Pelargonium was introduced into cultivation. A physician, experiencing difficulty in obtaining plants from foreign countries and knowing that the seeds of many choice varieties often lie dormant in the soil, commissioned a sailor to bring him a barrel of soil from the Far East—I believe from Borneo.

When the soil was received and spread out and cultivated, numerous plants sprang from it, among others the one that became the parent of the now greatly prized race of Pelargoniums.

Whatever the truth of this anecdote, it at least illustrates a possible way of securing new plants from foreign countries. And however the Pelargonium was introduced, it has proved a plant worthy of the fullest recognition. It has, indeed, obtained such popularity that the old-fashioned types of geraniums have in many places lost their vogue.

Hybridizing the geraniums is not at all difficult when one understands the process. It is only necessary to understand that the stigma of any given flower does not mature until after the pollen of the same flower has been scattered. Bearing this in mind nothing more is necessary than to gather

pollen and dust it on the stigmas of plants that have already shed their pollen. To make absolutely sure about guarding against the self-fertilization of the flower, it would of course be necessary to remove the stamens before ripening.

Some of my experiments in hybridizing have been conducted with the idea of producing fragrant races of geraniums. The chief difficulty in this work is that most of the fragrant geraniums have been grown for such a length of time from cuttings that they have for the most part lost the power of producing seeds. This makes it obviously difficult to secure seeds from the plants that are precisely the ones it would be desirable to use for the purpose.

Nevertheless I have produced a number of varieties having fragrance of very attractive quality.

One of these fragrant varieties is developed from a compact growing Australian form which produces an enormous amount of seed. If this form were crossed with the other fragrant varieties a valuable type should be produced, as this plant has recently come from the wild and would instill vigor into the specialized and long cultivated plants.

A line of work that I carried out at one time involved the crossing of the Pelargoniums with variegated leaves with those having ordinary green

Selected Chinese Pinks

Here is an exceedingly prolific Chinese pink plant that has been selected among many hundreds of its fellows because of its hardiness and capacity for production of a large number of flowers of excellent quality. The good traits of this plant will be accentuated by "line breeding."

leaves. Among these crossbreds it appeared that the green colored foliage was prepotent or dominant over the white and yellow variations. The horseshoe variations were more readily transmitted, but there was a varying proportion of marked and plain leaves among the hybrids.

I also worked at one time in selecting the geraniums for the production of large flowers of dazzling brilliant scarlet color, and with a good measure of success. One of the varieties thus produced has been greatly admired by all who have seen it, and will probably be thought worthy of introduction.

It will thus appear that there is abundant opportunity for improving the geraniums even by working with the species ordinarily under cultivation. I repeat, however, that the best opportunity for work in this line will involve hybridizing experiments in which the exceedingly hardy wild species are utilized. It should be possible thus to produce new races of geraniums that have altogether exceptional quality.

The wild species include some that are white in color as well as those that are pink or white striped with pink or with reddish veins. So there is opportunity to have a wide choice as to color variation. The cross might likely result also in giving the geraniums enhanced vigor so that new

races of perpetual bloomers comparable to the best of pelargoniums would be produced. Few plants among all the popular favorites have greater merits than the geraniums, and none, perhaps, offer better opportunities for interesting experiments that may be made by the amateur.

—A plant which has been worked on by experimenters for two thousand years presents a difficult problem for anyone who strives to develop new races of unusual value. It is like working against the traditions of the ages to attempt to modify the characteristics of such a plant in a new direction.

The Everlasting Flower and Some Common Exotics

The Australian Star-Flower and Plants from Orient and Tropics

NOT long ago I received a tentative order for ten million clustered flowers in a single lot. The order came from a French milliner, who stated that unless he could get at least ten million blossoms he could not afford to handle them at all. I was too busy with other things to attempt to fill the order, but the fact that it was given is worthy of record as illustrating the more or less unexpected opportunities that open up before the plant experimenter.

The flowers that the French milliner wished to use in such quantity are species of *Composites* known commonly as Everlastings. These flowers have long been popular because they retain their form and color more or less clearly when dried, and thus make permanent bouquets. In recent years, however, the abundance of fresh cut flowers has caused the everlastings to be much less popular than they formerly were.

Now, however, it appears that a process has been perfected through which, by chemical treatment, the dried everlasting flowers are given a degree of permanency and toughness of fiber that makes them suitable for use in trimming hats. Moreover, the grace and beauty of the new Australian star-flower are qualities not possessed by any other everlasting. Hence the milliner's desire to secure them in quantity.

Although I could not undertake to meet so comprehensive a request, I have nevertheless been experimenting for a number of years with various tribes of everlastings. These are plants that originally came from the Cape of Good Hope, and are hence known commonly as the Cape everlasting. There is an Australian star-flower that is pretty closely related, which is also an everlasting, and it is with this that my chief work has been done. This was sent me by my collector in West Australia, who first discovered it.

With the more familiar tribes of everlastings I have been well acquainted since boyhood, but it is only in recent years that I have given them serious attention. They are of many colors—red, pink, crimson, yellow, orange, and white. Some of them that are annuals in the eastern states became perennials in California, even growing throughout the winter. The everlastings with which I have ex-

Australian Star Flower

This is the everlasting flower that a ***Paris*** *milliner found so attractive that he wanted Mr. Burbank to raise ten million of them for him. Mr. Burbank was unable to undertake the contract, but the fact that the offer was made suggests the unexpected commercial possibilities that sometimes arise in connection with an e x p e r i m e n t in plant development.*

perimented most extensively belong to the genus *Helipterum,* and are known to the horticulturist as *Rodanthes.* My work commenced with a so-called double Rodanthes, which varies from white to red in color.

The seeds that furnished the original stock were said to represent a double flower, but only a small proportion of the plants that grew from them bore flowers that were really double. That is to say, there was almost invariably a center devoid of petals. My work consisted in selecting to fill up the center, and make a flower that is altogether double.

The flowers vary much in size, and the colors are so variant as to supply good material for selection. But a difficulty arises in that the plants produce very little seed. My selective experiments have now extended over a number of years, and I have been able to increase the size of the flower, to improve it considerably in the matter of doubleness, and to isolate to a certain extent the different colors, although the plant as yet is not fixed in any of these regards sufficiently to justify its introduction. The improvement already shown, however, justifies the expectation that varieties of this everlastings could be developed that would show marked improvement over old types.

I am experimenting also with everlasting flow-

ers of various other genera, including a *Gonohrena,* the seed of which was received from South America. This plant has been under cultivation for many years. It is a low growing plant, having globular, crimson flowers. The introduction of new blood from the wild South American representative may be expected to have the usual stimulative effect, increasing the vitality of the plant, and perhaps urging it to greater variation.

The Australian star-flower first mentioned in this chapter most resembles Rhodanthea, but is as distinct as a rose is from a carnation. The botanists have not been able to decide as to its specific name. With the exception of the Rhodanthea, this is without doubt the most beautiful of all the flowers called everlastings so far discovered or produced. The beautiful star-shaped, rosy-crimson and white clusters of flowers, produced in the greatest abundance, are surpassingly beautiful.

The plant is an annual, produced only from seed. The reason that this flower has not been more generally grown all over the world is that it is peculiarly subject to the attacks of soil fungi. On virgin soil it always thrives; on cultivated soil, sometimes. There is no doubt that this most beautiful of everlastings can finally become immune to fungi in cultivated soil through selection.

My work with the Australian star-flower has

A Single Australian Star Flower Plant

It will be seen that this is an extraordinarily prolific plant, growing blossoms by the hundred. This is a plant selected from among thousands of others of the same species. A glance at this plant suggests that the project of supplying ten million star flowers for the use of a milliner is not as hopeless as it seems at first blush. Mr. Burbank might readily have filled the order had he not been preoccupied with other tasks.

consisted of increasing the size of the blossom, making it semi-double, giving it added brilliancy of color, and to some extent rendering it resistant to disease. This has been accomplished by the usual method of selection, strings being tied about the better specimens, and finally the one best being saved for seed. Very great improvement was made, considering that this was a wild plant never before under cultivation. The selected varieties do not as yet breed true from the seed.

The Tribe of Crinums

In an earlier chapter mention was made of hybridizing experiments in which certain members of the amaryllis tribe were crossed with certain of the Crinums. It is desirable to make additional reference to some experiments in which the crinums themselves were variously developed and hybridized with rather striking results. The hybrid Crinums are a really splended group of bulbous flowering plants in which the bulbs are in many cases of enormous size, and the leaves are broad and long, making the plants very conspicuous.

Some of the leaves, indeed, are of gigantic size, and the stalk that bears the flowers may grow to a height of from four to six feet. The flowers themselves are of variant color, from white to rosy pink, and sometimes almost purple. They are

borne in profusion, and their attractiveness is often enhanced by their fragrance.

The crinums were originally residents of the tropics, being indigenous to various parts of South America, the southern United States. There are several species that are hardy in California. In some cases they will withstand freezing, so that even if the leaves are destroyed by the frost the new growth will put forth in the spring, and they will bloom as abundantly as if they had been carefully housed over winter.

Like most other bulbous plants they thrive best in sandy soil.

Some of the crinums are evergreen under ordinary temperature, others are deciduous like most of their relatives of the amaryllis tribe.

The chief objection to the crinums for house culture is the enormous size of the bulb, and the tendency to produce a superabundance of foliage out of proportion to the number of flowers; although this criticism does not apply to all of them.

Ten or twelve years ago I had probably twenty species of crinums, some of them having been brought from the tropics. My object was to combine the good qualities of the tropical and subtropical species with those of the hardy ones that had become acclimated in California. No difficulty was experienced in crossing the various spe-

A Burbank Crinum

The crinum is an interesting member of the amaryllis family, with which Mr. Burbank has performed a very large number of interesting experiments. Unfortunately the crinums are not very hardy, else they would be much more popular in our gardens than they are at present.

cies, and hybridization was carried out in the usual way, different pairs of species being mated and then the hybrid forms in subsequent seasons remated, noting of course at all stages which combinations seemed to produce the best results. Mixed hybrids were finally produced that combined the strains of many species.

The results were highly interesting.

In the course of a few years I had a strain of crossbred crinums presenting most of the desirable qualities of the different species in combination. The new plants, in spite of the strains of tropical species in their germ plasm, are very hardy, withstanding the coldest weather of this region without injury. They have very large flowers, varying in color from white, pink, and rosy crimson to purple. The petals are broad, and the flowers in a large number of cases are fragrant.

The bulbs of some of these hybrids have taken on extraordinary growth. At four years of age some of them are from six to eight inches in diameter, and twelve to eighteen inches in length, weighing probably from ten to fifteen pounds, or even more. More recently specimens have appeared of even larger dimensions. Some of these enormous bulbs seldom make offsets, others produce from one to twelve or more offsets in a season, so that they can be multiplied quite rapidly.

The seedlings from these hybrids produce plants that as a rule show a combination of two or more of the species fairly well balanced. The seed parent of the larger number of my hybrids is the *Crinum Americanum,* but in some cases the *Crinum amabale,* or the *Crinum Asiaticum* was the seed parent. It is observed that a certain small percentage of the hybrids show a strong propensity to run toward the seed parent of whatever species. This can generally be detected by the foliage when the plants are quite small. I have not observed that any of the hybrids depart so strongly the other way toward the tropical species (the pollen parent).

In the second and third generations the variations are better balanced through selection, and become more fixed in desired qualities than at first, when grown from seed.

On the whole, it is perhaps a little easier to get new species of crinums by crossing and selection than with most other bulbous plants, especially the lilies — although there are notable exceptions among the California lilies, some of which cross very readily.

I have sold a number of the hybrid varieties of crinum, but they have been introduced unnamed, or at least were not named by me.

The crinum seeds are very curious, in that they

An Improved Burbank Crinum

This sturdy plant, with its beautiful lily-like flowers, is an improved variety of crinum, developed by selective breeding. It is a flower meriting a place in any garden.

vary enormously in size, almost always in the same capsule. The pale-greenish bulblike seeds with irregular corrugations may vary from the size of a pea to that of an English walnut. When placed in a graded sequence they present a curious contrast. Yet the plants grown from the smallest seeds are likely to be quite as large and of the same appearance and quality as those grown from the mammoth ones. The seeds of the crinum thus furnish a unique link between seeds, buds, and bulbs, suggesting the properties of all these combined.

Another peculiarity of the seeds is that they contain so much nutriment and moisture that they may sprout and grow, making plants of considerable size, without access to any moisture except that contained within the seed itself. I have known them to sprout when laid on a shelf, or in envelopes, away from the light and entirely dry; also when sent to me by mail from Australia they sometimes started as seeds and arrived here in envelopes as small growing plants.

The crinums have been under cultivation for a long time, and interesting hybridizing experiments were made with them a century ago by the Rev. W. Herbert, Dean of Manchester, whose experiments with the gladiolus and other flowers have been elsewhere referred to. But there are many

species that have not been so largely experimented with, and the opportunity to introduce new forms from the tropics, together with the striking character of the plants themselves, gives them peculiar attractiveness for the experimenter. The possibility of making still wider hybridizations, as in the case of the cross with the amaryllis, and further selections, should of course not be lost sight of.

The Spectacular Ixia

Another tribe of bulbous plants that have great interest is that represented by the genus ixia. These, like so many other of the interesting bulbous plants, are natives of the Cape of Good Hope, and they are closely related to the gladiolus, and resemble many other Cape bulbs, including the Watsonias. There are various species, but they have been so intercrossed and mixed that the experimenter need pay very little attention to specific names and distinctions. The bulbs are inexpensive, and are commonly grown several in a pot in the house in winter in the eastern states, but in California they grow outdoors, and there is no occasion to transplant them, except for propagation.

A single bulb will spread by putting out new bulbs, which in turn make offshoots in the same way, until a large and beautiful clump of plants is often developed. The ixia, indeed, can never be seen at its best except when grown in this way.

Hybrid Crinum

Mr. Burbank has hybridized the crinum with the true amaryllis, producing a plant with enormous bulbs and with pleasing, if not particularly spectacular, flowers. Unfortunately the hybrids do not bear seeds, although they blossom freely. So the experiment has not been carried beyond the first generation.

The flower stems are thrown up in great abundance on long, stiff, wiry stalks, and the graceful upright or drooping flowers are of every color except blue—crimson, yellow, and white being the characteristic colors.

The variety of ixia known as the Wonder has double flowers that are exceptionally handsome. The group of ixias make so striking an appearance that they compete with the giant amaryllis in my gardens in May for first place in their appeal to the average visitor.

The two plants are utterly different, but each in its way is most individual and striking; the ixia being characterized by gracefulness and fragile beauty, the other by its massiveness. The flowers of the ixia are only about two inches in diameter; those of the others eight to ten inches, yet the massed effect of the ixia is so striking that it competes in interest with the larger flower.

I have worked in a more or less desultory way on the ixia for the past dozen or fifteen years. The varieties under cultivation are so mixed as to their ancestry, and hence have so strong an inherent tendency to variation that it is not necessary to cross them. Even the double variety is probably at least half a century old. My work of improvement looks to the increase in size and brilliancy of color of the flower; and, of course, here as

always, attention is paid to gracefulness and abundance of blooming, and vigor and general health of the plant.

The improvements in all these regards have been quite striking, although I have not considered any individual variety worthy of introduction under a new name.

Notwithstanding the amount of work that has been done with them, the ixias will well repay the attention of the amateur who cares to work with them.

Oriental Poppies

In an earlier chapter an account was given of my blue poppy. An account has also been given of the development of new colors in the flower usually called the California poppy, but more properly known by the somewhat forbidding name of *Eschscholzia.* Very little has been said, however, about the experiments with the well known annual and perennial poppies, which have produced some results of considerable interest.

The poppies in question are the opium poppy (*Papaver somnifera*), and one previously called the Oriental (*Papaver orientalis*).

The opium poppy is, as everyone knows, a commercial product of vast commercial importance in the Far East. It has been under cultivation in Europe to a greater or less extent for several

Seed Pods of the Crinum

The seeds of the crinum show an extraordinary range of variation, some of them being small, whereas others are so large as to suggest miniature bulbs. The latter are so succulent that sometimes they sprout when lying on the shelf. On one or two occasions Mr. Burbank has had crinum seeds sent from a distance by mail, which sprouted en route. This is an interesting and very unusual peculiarity.

centuries, and has been greatly improved by the European growers, the varieties developed being of almost every shade of color, some flowers being single and others double.

From time to time charming varieties have been sent out in recent years, including an interesting single one known as the Miss Sherwood, a variety having blossoms with a white center and crimson edge, the petals being beautifully fringed.

There are other varieties known as Paeonia and Carnation Flower poppies that are double and are exceedingly handsome in color.

The Oriental poppy has very large flowers, always crimson with shadings of scarlet in color in a state of nature, and in almost all cultivated varieties—the color being unusually well fixed. The plant is a perennial with rough, hairy leaves. The flowers are borne on single stems, instead of branching from a main stalk as in the opium and most other poppies. The Oriental species has probably not been under cultivation as long as the other, but many varieties have been developed, some of them semi-double, and the colors have been modified so that there are dull white, scarlet, and yellowish varieties, as well as the more usual crimson.

These varieties, however, seem not to be well fixed—they do not come true from the seed—and

the best varieties so far produced quite generally appear to be lacking in vitality — possibly from overzealousness in selection by division, the only way of maintaining and multiplying any special variety.

My own experiments have largely had to do with hybridizing the Oriental and the opium poppies.

Rather curiously I found that the pollen of the opium poppy was ineffective when used on the Oriental, yet when a reciprocal cross was effected, the pollen of the Oriental being used on the opium poppy, seed was produced, and a great number of hybrids were soon under observation.

In the hybrid colony, comprising more than thirty thousand of these plants, there was as little variation in color as is usual with the Oriental poppy. None of the hybrids were double, but they had several interesting qualities.

One striking peculiarity was that the hybrid poppies produced in some cases enormous seed capsules, five or six times as large as the ordinary seed capsule of either parent species. Yet in other plants the seed capsule would be smaller than that of either parent. In still other cases twin capsules are produced uniformly, and with a certain number there was produced a mere rudiment of a capsule. But the most striking of all were the

Chinese Opium Poppies

This is a variety of the flower, from the seed heads of which the familiar commercial drug, opium, is extracted. Mr. Burbank has experimented extensively with this as with many other species of poppies, though not, of course, with reference to its opium-producing qualities.

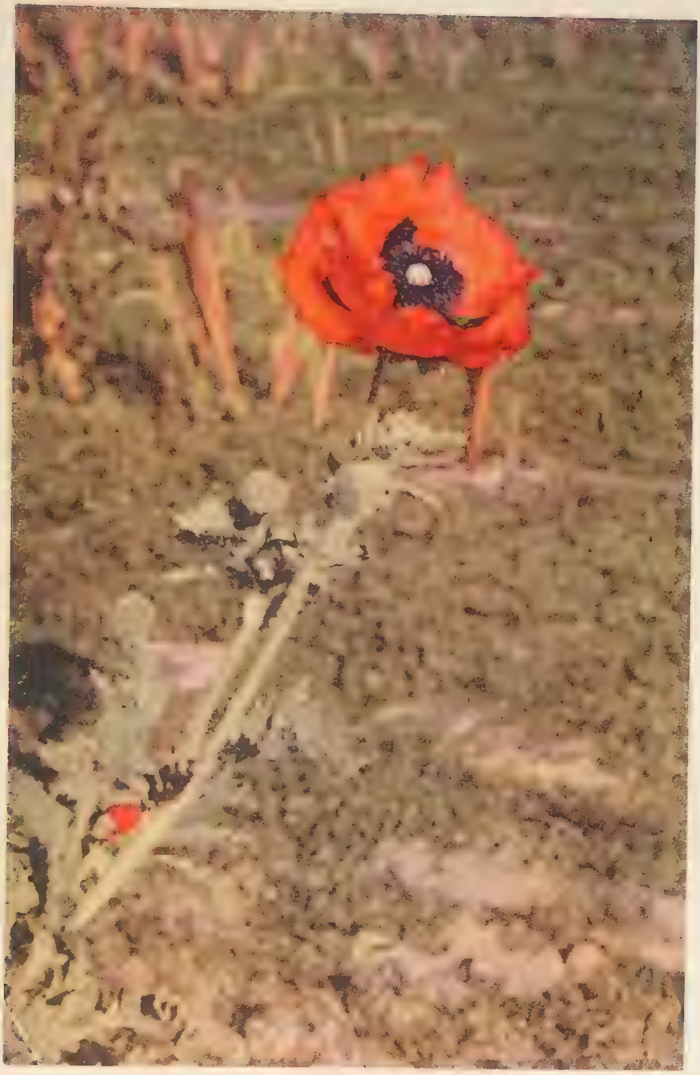
numerous plants that produced not even an intimation of a capsule, the flowering stem ending abruptly like the end of a lead pencil.

All in all the hybrids showing this extraordinary variation in the seed bearing capsule—ranging from enormous enlargement of the capsule to its entire obliteration — make a very wonderful and interesting study in heredity.

It is of further interest to note that, although these hybrids were raised from seed of an annual poppy (hybridized, however, by a perennial), yet without exception every member of the entire company of thirty thousand is a perennial.

The flowers, themselves, vary greatly in size, some of them being seven or even eight inches in diameter, while the smallest are perhaps only four or five inches. Some are beautifully crimped, others have flat petals, there being the most striking variations in form.

Even the specimens that have unusually large, plump seed capsules may produce no thoroughly well developed seeds. In a gallon of the seedpods, from which one might expect perhaps two quarts of plump seed, I usually obtain perhaps from one hundred to three hundred or four hundred grains, mostly of shrunken ill-shaped seeds. Yet these shriveled seeds when sown produce good plants. Even seeds that seem so abortive that it is



Another Specimen of the Chinese Opium Poppy

It is probable that the Chinese opium poppy represents the result of careful selective breeding on the part of unknown plant developers. But the development of its drug-bearing qualities has not interfered with the beauty of the flower, as is evident from a glance at the specimen here shown.

incredible they should germinate, may produce perfectly healthy seedlings.

STRIKING VARIATIONS IN THE SECOND GENERATION

The second generation poppies produced from these seeds were among the most remarkable companies of plants that I have ever seen. All who saw them agreed that they were the most variable lot of plants of a single fraternity that they had ever observed.

The diversity was so great that it might be said that there were no two plants among the thousands that were even approximately identical. No two could be found in which differences could not readily be observed in the foliage.

Some of the peculiar forms of leaf were these: (1) Long, smooth strap-shaped leaves sometimes not more than half an inch wide and a foot or more in length; sometimes smooth and sometimes villous; dark green or light green. (2) Short and stubby leaves, trifoliate, either villous or glaucous. (3) Leaves resembling those of the Oriental poppy. (4) Leaves like those of the opium poppy. (5) Nondescript leaves, variously suggestive of the leaves of primrose, cherry, dock, wormwood, dandelion, and scores of others.

It is interesting to note that the blossoms of the second generation varied somewhat less than the leaves, although much more diversified than

A Hybrid Poppy

Mr. Burbank's experiments in hybridizing the poppies are of exceeding interest. Here is a specimen of a cross between the opium poppy and the oriental poppy. The anomalous results of this combination, of great interest to students of heredity, are related in the text.

the blossoms of the first generation. Some were double and of various shades of the opium poppy. The range of color included almost black, deep crimson, purple, light crimson, salmon shades, pink, white, and various combinations of these colors. Yet on the whole the color variation was not greater than that ordinarily found in the opium poppy.

The second-generation plants seemed not to have the vitality shown by those of the first generation. There were exceptions to this, however, individual plants manifesting a vitality in excess of the average of the first-generation plants.

Most of the second-generation hybrids that produced double blossoms proved to be annuals or biennials, partaking thus of the characteristic of the parent from which they derived their doubleness of blossom. This is perhaps what might have been expected. It is notable, however, that the quality of annual or biennial growth should have reappeared in these hybrids of the second generation, the first generation hybrids having been, as already noted, all perennials.

But, on the other hand, some of the second generation hybrids were perennials, and have continued to live and thrive, bearing large quantities of blossoms each season.

Thus the perennial and annual habit appeared,

Giant Oriental Poppy

The selected poppies sometimes attain very extraordinary size. This blossom measured almost a foot across. Few flowers afford greater interest for the amateur gardener than this spectacular visitor from the orient.

A Bed of Oriental Poppies

Any amateur may repeat Mr. Burbank's experiment of crossing this poppy with the opium poppy; and the results are sure to be full of interest. Hybrids of such parentage are to be seen blossoming at almost any season in Mr. Burbank's gardens at Sebastopol.

in the case of these two poppies, to be a pair of unit characters of which the perennial habit was dominant and the annual habit recessive; there being a characteristic segregation in the second generation.

As to habit of blooming, there was another interesting anomaly. The opium poppy, a strict annual, blossoms only for a short period—for a few weeks at most. The Oriental poppy, although a perennial, also blooms but a short time. The first generation hybrid poppies bloom persistently. There is not a day in the year when some of these hybrids are not in bloom, spring, summer, autumn, or winter—blossoms can always be gathered in quantity from them.

The hardiness of the hybrids has not been fully tested. I should not be surprised to find that they are largely as hardy as the Oriental poppy, but the California climate does not subject them to a severe test.

The Third Generation Hybrids

In the third generation, a large number of the hybrids reverted toward one or the other of the original parents. But even those that resembled one of the parents or the other strikingly, retained also traits of the other parent. In this generation the plants mostly produced no seed, and the tribe partially ran out.

Japanese Ophiopogon

This is another visitor from the orient with which Mr. Burbank has experimented somewhat extensively. The plants here shown have been improved by selective breeding, but they are still at the experimental stage of development. They make an unusual and interesting addition to the flower garden.

All these unique hybrids present such interesting characteristics that it will be worth while to record that the opium poppy that was used as the original parent was of the Miss Sherwood variety, but that later other opium poppies of every shade and color that could be obtained were also used. Perhaps in all twenty-five or thirty selected varieties of opium poppies of various colors and different forms were used as seed parents. The progeny, however, as far as I could observe, varied little and was not greatly influenced by the different type of opium poppy used. However, the variation was so great in any event that it would be difficult to judge as to this.

In general, the minor colorings and doublings of color seemed to have less effect in the heredity than the more fixed original foliage and flowers of the wild plants. The hybrids show doubleness and selected colors very slightly, except in a few cases in the second generation, when there was a tendency to return toward the original forms. It should be noted also that the Oriental poppy, although failing of fertilization when treated with pollen of the opium poppy, produced seeds abundantly when fertilized with its own pollen.

The size of the pollen and length of the pollen tubes may conceivably have something to do with the failure to effect hybridization when the Ori-

ental poppy was used as the pistillate parent; but this is only conjectural. Also, the opium poppy has been so long under cultivation, and has become so adaptable, that it perhaps is more pliable and more ready to receive strange pollen.

The relative sterility of the first-generation hybrids may be judged from the fact that almost five thousand seedlings produced ten or twelve gallons of capsules, but that there was only about a quarter of a teaspoonful of seed to each gallon of capsules.

As these seeds were shrunken and much smaller than ordinary poppy seeds, however, the actual number of seeds was proportionately large. Still the total number was only a fraction of what would have been the output of poppy plants of normal fertility.

All in all, this experiment of hybridizing the Oriental and the opium poppies, with the production of relatively infertile hybrids showing Mendelian heredity as to some traits and a blending of characters as to others, and a further segregation and recombination of characters in the second generation, constitutes an unusually interesting experiment in heredity. I have made many other experiments in breeding the various poppies, but none perhaps that excelled this one in interest and importance.

The Hybrid Larkspur—and Other Transformations

Introducing a Miscellaneous Company

THE members of my larkspur colony are all descended from a single individual.

That individual, in turn, was the select and peerless member of a company of five thousand, all of them of equally aristocratic lineage, and each one of them worthy to show itself in any larkspur company. But the usual rigorous method of selection was applied to them.

The one individual that came nearest meeting all expectations was preserved. The rest were sent, with sundry thousands other plants of divers species, to the bonfire.

The selected individual, of course, became the progenitor of a new colony of larkspurs. Some of these improved upon their ancestor, and among them several interesting varieties were isolated through selection.

The original parent form from which the one

best larkspur was selected as the progenitor of new races was of the species known as *Delphinium hybridum,* or hybrid larkspur. As the name implies, this plant is itself of hybrid origin, but it has been cultivated a long time in Europe, being unusually popular in England, and ranks as a true species, or at least as a good horticultural variety.

There are numerous other species of larkspur, sixty or more altogether. Some are annuals and some perennials. Our native California species are among the most beautiful. One of these, named *nudicaule,* is a perennial growing along the sides of streams and in shady canons, although on occasion even mounting to the tops of high rocks. It bears flowers of a bright orange red, sometimes varying to yellowish, that are very showy. The plant is easily cultivated either from seed or by division, as indeed are all perennial larkspurs.

Another species is *D. cardinale,* a large, strong plant, growing in the southern part of California, the flowers of which are also bright red and yellow though quite different in general appearance from those of the one just named. Yet another larkspur that is of interest is the *D. decorum,* an extremely variable form growing usually on overflowed land.

The flowers of this wild species vary almost as much as do our hybridized and cultivated ones.

Improved Hybrid Larkspur

Few of Mr. Burbank's flower productions are more popular than his improved hybrid larkspur. This picture suggests that the flowers amply justify their popularity. They are the product of hybridization, as their name suggests, combined with careful selective breeding.

Growing side by side in a bed of wild larkspurs of this species may be found plants bearing flowers varying from deep blue, pale blue, dark rosy pink, pale pink, and yellow, to almost pure white. The flowers of these are quite large and showy, but the colors, although so variant, are seldom brilliant.

The larkspur known as *D. Californica* is a giant species, often found in canons toward the coast. For a larkspur it towers to a great height, sometimes reaching seven or eight feet, but the flower is insignificant when compared with most other varieties both in size and color. They are purplish blue or dingy white in color.

My attempts to cross this species with some of our cultivated ones have not resulted in producing anything of value.

Still another species is known as *D. hespirium.* It grows in sandy or heavy black soil as the case may be; is about two feet in height, and bears flowers that are almost invariably of deepest blue, although sometimes pink, pale blue, and white ones are found.

These wild species are mentioned somewhat in detail, chiefly to show the variation among them, suggesting the possibility of interesting developments when the various forms are combined. I have utilized them all more or less in experiments, and in addition have grown nearly all the lark-

spurs that are ever offered by seedsmen or florists. As already stated, my chief experiments began with the use of the hybrid larkspur as a seed parent, but of course the hybridizing experiments soon blended the strains of many of the other species, until the larkspur colony, like so many others of flower groups, is of such conglomerate ancestry that the precise proportions of the different strains in any given race are not traceable.

Needless to say, selection has been carried forward along with the hybridizing experiments, these two methods always being complementary. Particular attention has been given to size of flower, vigor of plants, and resistance to insects and disease, as well as that of multiplication by division, at the same time that compactness of growth and brilliancy of color of flower have been carefully regarded.

One of the worst faults of the larkspur is that it tends to grow too tall, with a stalk that does not support it, so that it requires to be staked. But my hybrid larkspurs have been so selected that they are compact in growth, and able to support themselves even in a moderate gale.

All the characteristic larkspur colors are represented among the new varieties, and in addition there are combinations of color that have never before been seen, I think, in the larkspur. Some

Color Variations in Hybrid Larkspurs

The hybrid larkspurs are very pleasing in form, and the compact clusters in which they grow are peculiarly attractive. But their other good qualities are enhanced by the wide range of color variation, of which a suggestion is given in this picture. The range of colors is striking, and all of the colors are pleasing.

of the individual flowers are considerably over two inches in diameter, and some of the largest are very double.

The color yellow is not usual with the larkspur, its characteristic colors being red, blue, and white. There is one yellow species, a native of southern Asia. I have, however, developed varieties with pale yellow flowers. The best of the selected varieties, as descended from the original one chosen among the first five thousand, is known as Burbank's hybrid, and has been given full recognition by seedsmen, florists, and gardeners. There is still opportunity for further development among the larkspurs, however, and improvements may be expected which, if not spectacular, have at least a fair measure of interest.

No plant is ever so fully developed that it does not hold possibilities of improvement.

An Almost Endless Variety

The great family of composites presents an almost endless variety of flowers, of which we have seen some striking examples, most notable among these being perhaps the daisies and the dahlias. But now and again a new form makes bid for popularity, and there is still an indefinite amount of material among our wild plants from which garden plants might be developed.

Yet the old favorites are not necessarily sup-

planted. Indeed there are some of them that have perennial interest, holding their charm despite all competition.

One of these is the marigold, of which there are various species that find favor not only because of the ease with which they may be cultivated, but also because of the length of time during which they bloom, the abundance of blossoms, and their good keeping qualities after being picked.

The marigolds most commonly cultivated fall into two distinct groups, one spoken of as the African marigold and the other as the French marigold. In addition to these there are native species, among others a very interesting one that I have received from Arizona, sent me by Professor Lemon, whose name it bears. This native form is a shrub about four feet in height, and in the fall it bears a mass of beautiful single golden flowers about the size of the French marigold.

This is one of the handsomest shrubs of this sort, and although I think it has not yet been introduced, it deserves a place in every garden, if—as has not yet been proved—it will stand the colder climate.

My experiments with the marigold were conducted a good many years ago, chiefly along the line of crossing the French and African races and this new Arizona perennial species. In addition

A Brilliant Specimen

This is one of the most brilliant of the hybrid larkspurs. It is a variety distinguished also by the large size of its flowers and the wonderfully compact and symmetrical clusters. A flower like this is a treasure in any garden.

to their practical horticultural results, the experiments gave some interesting illustrations of hereditary influence.

In particular I observed that when the double marigolds were crossed with the perennial single species above mentioned all the hybrids were single. Moreover, if I am not mistaken, they were all annuals, though the perennial marigold was the mother plant in every case.

It is interesting to recall that precisely the opposite result was produced in hybridizing the poppies. In that case the union of an annual and a perennial poppy produced hybrids all of which were perennials.

One of the best marigolds with which I have worked is called the lemonball. It is of the African type, and it produces great lemon-yellow blossoms in abundance, blooming throughout the entire season. The best specimens are thoroughly double, but if the seed is saved from the most double blossoms, almost half of the seedling will bear single flowers or those not perfectly double.

It is obvious that the factors for singleness and doubleness tend to be segregated, and that the strains of the double marigold have not all been isolated in such a way as to produce germ plasm that is unmixed as regards the factors for number of petals.

A Distinctive Cluster

It is difficult to see how this hybrid larkspur could be improved upon as to the symmetrical development of its flower cluster, and the uniformity and excellence of its individual blossoms, nearly all of which, it will be seen, are in full bloom at the same time. But in point of fact there are almost numberless varieties of equal merit among Mr. Burbank's hybrid larkspurs.

Presumably this could be done by careful selection.

My more recent experiments have to do with the general improvement of the marigolds, and I am also experimenting with a new species from Chile with reference to its possible value as a pot-herb for its fragrance and flavor. It is a tall, slender shrub with innumerable pale, straw-yellow flowers—almost white. Like one or two other species of the genus it has a most delightful fragrance and flavor. As regards quality and intensity of flavor, it surpasses all others, but it apparently has no other merit. Whether it will prove of sufficient value for introduction in the vegetable garden is still problematical.

A much less familiar member of the composite family which, however, has gained rapidly in popularity in recent years is the plant known as cosmos. This is a Mexican species that is now making its way into the flower gardens everywhere. It is related to the plant known as the black dahlia (*Bidens astrosanguinea*) botanically, yet the relationship is not so close that the two can be combined, at least I have not been able to effect crossing between them.

A peculiarity of the cosmos, due doubtless to its recent importation from a sub-tropical region, is its habit of blooming very late in the autumn.

A Flower Cluster of Many Colors

Here is a bunch of hybrid larkspurs combining delicate yellows, pinks, and blues. It would be an interesting experiment to take the seeds of this single flower head, and endeavor to produce, by selective breeding, varieties of larkspur having flowers of uniform yellow and pink and blue respectfully. Such possibilities as this are open to any one who wishes to experiment with this interesting flower.

This is sometimes regarded as a merit, but as the plant is very tender, there is danger that its blossoms will be blighted by the early frosts. So the most important work that has been done with the plant in recent years is the production of early blooming varieties. The effort has been so far successful that there are now varieties that bloom in midsummer. The fact that this modification has been brought about within a comparatively few plant generations illustrates the pliability of the cosmos.

It is, in point of fact, one of the most variable and pliable of plants—comparable in this regard to the dahlia.

Such being the case, it is not surprising that it has been found possible to develop new shades of color, as well as much larger and finer flowers than those of the original species. Forms with wider petals, and others with twisted petals and other variations of the corolla, have also been developed. Even a double cosmos has been mentioned as forthcoming. But the plant is comparatively new in the flower garden, and it offers therefore rather exceptional opportunities for the experimenter.

The amateur who is looking for a plant that has not been carried to anything like its limits of variation may advantageously pay attention to this graceful, attractive, and rapid-growing composite.

The extreme heat and long days of the summer even in high altitudes in the United States makes possible the cultivation of a large number of flowers that were originally of tropical habitat. Among these no others are more familiar or have retained their popularity more steadily than the tribe of plants of the genus *Iponoea,* which numbers among its representatives plants of such diversity as the morning-glory, the moon-flower, the cypress vine, the yam, and the sweet potato.

The Brilliant Morning Glory

It is not difficult to account for the popularity of the morning-glory. A vine that grows with the greatest rapidity and that bears flowers of striking and brilliant color in the greatest profusion, day after day, for weeks together, covering our arbors or pergolas in a few weeks' time, has merits that are not duplicated exactly by those of any other flower under cultivation.

The morning-glory has not been very extensively worked with, but it has shown a marked tendency to variation, and, as usual with plants under cultivation, has broken up into numerous varieties, showing in particular a wide range of color variation. One of the most remarkable of the varieties is the Japanese morning-glory, some forms of which have double flowers of very curious structure. The single varieties of the Japanese

More Hybrid Larkspur Variations

Compare this cluster of hybrid larkspurs with those shown in earlier pictures and in the succeeding one. After making such a comparison, no one will need to be told why the hybrid larkspur is an exceedingly popular flower,—particularly when it is recalled that, in addition to its other merits, this is a peculiarly hardy, thrifty, and prolific bearer.

type are of relatively immense size and of the most wonderful color. But they do not produce so abundantly as the common morning-glory, they do not climb as well, and they seem to lack the vigor of the ordinary form.

My experiments with the tribe have had to do with the crossing of several related forms.

The plants can generally quite readily be crossed, and the seed germinates readily. These experiments have not been carried far enough to produce any very striking results. It is obvious, however, that the morning-glory offers good opportunities for improvement, and the ease with which it can be cultivated makes it a plant that should appeal particularly to the amateur. The wide range of color variation, together with the fact that the colors are fairly fixed in certain varieties, make possible crossbreeding experiments that can readily be checked.

Possibly also it may be feasible to cross the morning-glory with the moon-flower or with various other members of the genus. The moon-flower itself, which produces large white flowers in great abundance, has been greatly improved by selection.

There is also an interesting Brazilian morning-glory (*Ipnoea setosa*) with a vine that grows with great rapidity and bears a rosy purplish flower,

Variable Clusters

These specimens of hybrid larkspur are selected as suggesting the considerable range of variation in the make-up of the clusters of blossoms. Note the very striking contrast between the cluster at the left and that at the right, the latter being the result of a long series of experiments in careful selective breeding. Compare this picture with earlier ones of this series, to suggest the full range of variation in form and color among the selected hybrid larkspur.

and a perennial tree morning-glory, a native of Texas, which bears very large light pink flowers in abundance. Indeed the number of species from which selection can be made is rather large, and variation among them sufficient to give the experiment in hybridizing exceptional interest.

Another vine-like plant from South America that has made its way into every garden is the Tropaeolum, commonly known as the nasturtium.

There are at least forty species of this tribe, mostly climbing natives of Peru and Chile. One of these, *T. puberosum,* produces spicy roots that are highly prized as foods, and its seeds are sometimes used in salads under the name of Indian cress. The seeds of the form familiar in our gardens are sometimes pickled, and it is probable that table products of greater value could be developed from these plants if attention were paid to breeding them with that idea in mind.

Some of the nasturtiums are exceedingly tender to the slightest chill, but they may grow in the hottest and driest soil.

My work with the nasturtiums has been done with specimens sent from South America by my collectors, representing eight or nine species. Some of these have bulbs that remain dormant in the ground for two or three years, and then sprout and grow very fine vines that climb over the bushes.

The common nasturtium of our gardens, *T. majus*, is one of the most readily grown of our annuals and has been so long cultivated and so thoroughly crossed that the colors of the flowers are exceedingly variable. In recent years very good work has been done, particularly by California cultivators, in the improvement of the climbing nasturtiums, and in particular by crossing the ordinary form with the one known as *T. minus*.

Both the parent forms and the hybrids have run into numberless colors, clear lemon yellow, flesh color, deep crimson, purple, scarlet, deep yellow and white, the colors being variously blended, and the foliage of the plant being sometimes most beautifully variegated. Even the form of the leaf has been changed, so that there now are ivy-leaved strains of nasturtiums.

The nasturtiums offer great interest for the amateur experimenter, as they are very readily hybridized, and as their range of variation, even without crossing, is so great as to afford the widest opportunity for selection. Indeed, crossing has been so fully carried out that for ordinary purposes selection will answer far better than further crossing. Indeed it is exceedingly difficult to keep the colors of the various nasturtiums separate. The seed of a pure white variety quite commonly may

California Morning Glory

This is one of numerous species and varieties of morning glory utilized by Mr. Burbank in his experiments with this flower. As some of the species come from the tropics, there is opportunity for the blending of widely different heredities.

produce various colors. And it is more difficult to fix these colors than is the case with most other flowers. But of course such difficulties only enhance the interest of a really earnest experimenter, and develop his enthusiasm.

Stamping Personality on a Flower

An illustration of the way in which the personality of the experimenter finds expression in the plants that he cultivates was furnished me a number of years ago by Mr. Peter Barr, a well-known horticulturist who specialized with the narcissus and daffodils.

On visiting my place a number of years ago, he related an experience that may be taken as typical, yet which the amateur who has not experimented extensively might regard as rather extraordinary. The story has been told in an earlier volume, but it may be briefly repeated here.

Mr. Barr stated that among the thousands of seedlings the whole stock of which he purchased of two specialists in England, he could always tell at once, on seeing the blooms, which of the two specialists had developed any individual plant, even though the varieties had been mixed.

One of the breeders produced very large, coarse flowers, gigantic and broad, and lacking in delicacy of contour. The other produced seedlings of graceful and exquisite form.

A Bed of Hybrid Morning Glories

Here are some of Mr. Burbank's hybrid morning glories, showing the not unusual propensity of hybrids to grow luxuriantly and bear flowers in profusion. This vine represents a stage of progress, rather than the completed product.

And these contrasting characteristics of the different daffodils, Mr. Barr assured me, typified the personalities of the two breeders by whom they were developed. One of these was a person of little refinement, notwithstanding his love of flowers; the other was a cultivated banker of artistic temperament. The tastes and propensities of the two men made themselves felt in all the flowers they produced; which of course was inevitable, when we reflect that the plants were produced by selection, and that each man naturally selected the type that appealed to him.

I cite the incident not as something exceptional, but as typical. Almost as a matter of course, one could draw correct inferences as to the personality of a plant developer from observation of the varieties that he has developed—provided always, of course, that his selections have been made along the line of his own tastes, and not to meet some specific commercial demand.

There should be for the amateur an added stimulus in the reflection that he is thus putting the stamp of his own personality upon the plants with which he experiments. The flowers of your own garden may thus come to have an individuality that represents you as fully as you are represented by your costume or by the books you gather on your shelves. And surely the possibility of

developing a flower garden that has such individuality, differing from any and every other flower garden in the world, should give the pursuit of the amateur florist unique interest.

Some Interesting Natives

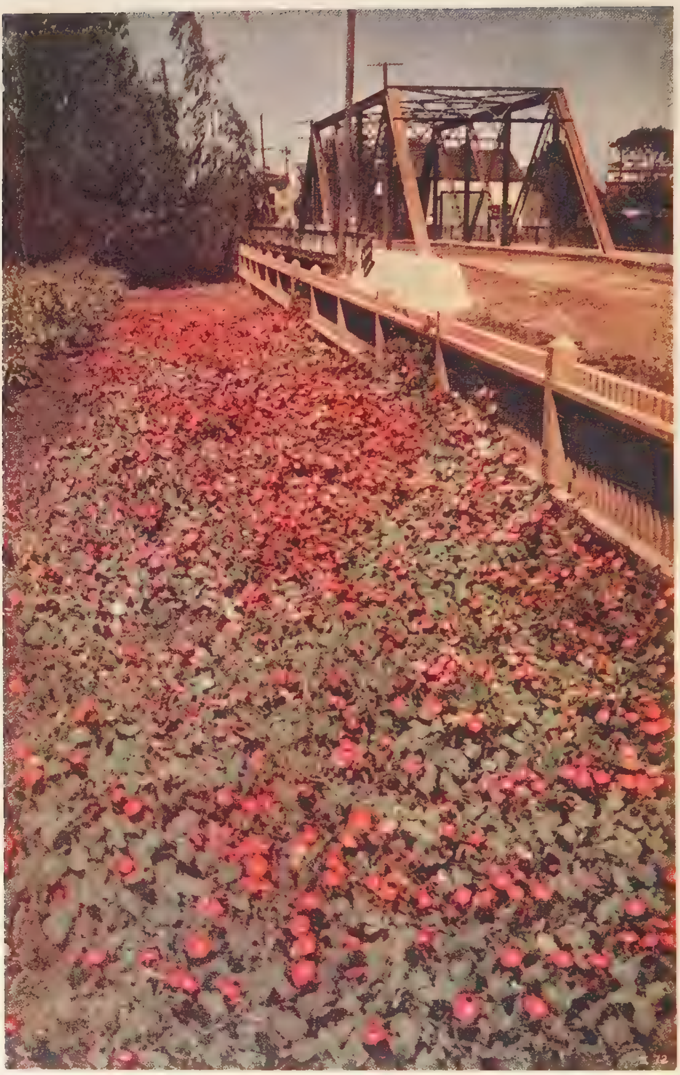
I have more than once suggested the possibility of introducing to the garden species of plants that grow in the wilds and that offer interesting possibilities of development. Two or three other tribes of these interesting wildlings may be here referred to. To name all that are worthy of consideration would take many volumes for there are more than ten thousand species of flowers indigenous to the United States, and of these only something like fifteen hundred have at one time or another been placed under cultivation.

I may name two or three familiar ones, in addition to those that have already been referred to, as offering exceptional attractions.

There are, for example, the Gilias, represented by many species. I have cultivated twenty or more wild ones at one time, selecting for brilliancy of color, for size of flower, for compactness of growth, or for some other desired quality.

On occasion I have carefully scrutinized at least ten thousand different plants in order to select the individual with which to begin improvements.

The gilias vary greatly in color, so that they are



A New Burbank Morning Glory

Quantity production again, with ample opportunity for selection, that the very best hereditary possibilities of the hybrid may be revealed. The variety here shown is one of the newest developments at Santa Rosa, as the morning glory experiments are still in progress.

very interesting flowers with which to work, and the colors may very readily be fixed in the course of four or five generations. So also may the qualities of compact growing, size of flower, and the like. The plants, therefore, are encouraging ones for the amateur who is anxious to get results.

The familiar milkweeds have been referred to in another connection with reference to the peculiar arrangement of their pollen masses, which are so adjusted as to entangle the feet of bees.

The amateur will find it peculiarly interesting to cross-pollenize these flowers. It will be advantageous to work with a magnifying lens of considerable power. The curious form of the flower and the unique arrangement of the pollen masses give the work of cross-fertilizing these plants a unique character, and these flowers are in general among the most puzzling of all flowers for the amateur.

There is possibility of developing, among the milkweeds, plants of commercial value. I have worked somewhat extensively with a number of unclassified South American species. For two or three years I carried on the work of selecting the best seedlings among a large number, until several races were pretty sharply defined. Now I am crossing the best of these, the object being to get varieties of more beautiful blossoms for garden

culture, and also to secure varieties that will be of value in producing a fiber that has something of the quality of silk.

Even now tons of milkweed seed pods just before they are ready to open are dried in the Mississippi Valley and shipped to Japan, where they are used to make a kind of felt. In the Philippines there is an allied plant, the Kapok, which supplies a fiber much used for filling pillows and the like.

It is considered within the possibilities that a variety may be produced that will be of value for the production of rubber, as the juice of some species has excellent rubber qualities.

The native varieties of milkweed are exceedingly hardy and as they are perennials they may be worked on season after season. There is great variation as to vigor of growth, size of leaves, compactness of plants, and color and form of leaves, as well as regarding the size, color, and abundance of blossoms. The seed pods, with their white, silk-like fiber also vary greatly. And there is corresponding variation as to the amount of latex or milk produced by the stalks.

All in all, then, there is scarcely another tribe of plants that shows a wider range of interesting qualities for observation of the experimenter.

Another wildling offering attractions of a different character is the so-called painted cup, or

Seed Pod of the Milkweed

It has been more than once suggested that the "cotton" of the milkweed pod might afford a textile product of commercial value. Be that as it may, the downy mass in which the seeds are embedded is of peculiar interest, and it would be well worth while to attempt to improve the quality of this fiber by selective breeding. We have seen in another connection that the flower of the milkweed also has peculiar interest for the would-be pollenizer.

Indian's paint-brush, classified by the botanist as *Castilleia.*

The most familiar form of this plant is the one known for its brilliant scarlet color. But the tribe is exceedingly variable, and the different members present flowers that range from scarlet, crimson, orange, yellow, and purple to pure white. Some are variegated. Individual plants of the first named species growing on the same cliff along the shore may show the widest range of variation in the color of their blossoms. Indeed, all colors are sometimes combined in the flowers of a single plant.

In other cases one will find a small patch of yellow flowers in one place, and in the neighborhood another patch of orange colored or of white ones.

The only color that is missing is blue. It would thus be an interesting quest for some plant developer to see whether he could develop a blue painted cup, somewhat as I was able to develop a blue poppy. Even failing in this, the opportunity to study heredity of color, and to isolate races of painted cup of one color or another, attempting to fix them so that they would come true from seed, would give recreation for a number of seasons.

The fact that the painted cup does not always prove easy of cultivation suggests that it is a plant

worthy the attention not merely of the beginner but also of the amateur who has gained a measure of experience, and who is willing to try his hand at problems of plant development that are not free from difficulties.

As I said before, it would be possible to extend almost indefinitely this list of interesting flowers that invite development. But the ones named may serve by way of introduction, and the amateur may readily extend the list by looking about in almost any garden or by rambling almost anywhere along country roads or in neighboring fields.

—The material lies everywhere about us, and despite the activities of large numbers of flower lovers, there are hundreds of species readily accessible that have never come under the hand of the cultivator, and which therefore have the attraction of entire novelty.

Decorative Palms

No other plant quite takes the place of the palm as a lawn decoration. It is to be hoped that breeding experiments will sometime be carried out through which a hardy race of palms will be developed, so that such a view as that here shown may become familiar in the eastern states as it now is in California.

Ornamental Palms and Climbing Vines

Views on Artistic Treatment

VISITORS from the East are often surprised to find palms growing thriftily at Santa Rosa. The average resident of northern latitudes appears to associate the palm with tropical conditions. And while it is known to everyone that these trees grow in Southern California, it seems a matter for wonderment that they should be found so far to the north as the region in which my experiment gardens are located.

In point of fact, isothermal lines make no difference in California, as the winds from the Pacific, deflected by the mountains, determine the climatic conditions, and produce quite unpredictable results. Thus it is that oranges are sold from northern California before they are ready to pick in the southern part of the state.

And again, the palm is a relatively hardy tree—I mean, of course, in comparison with tropical

plants in general. And whereas the date palm does not thoroughly perfect its fruit, for the most part, except in regions where the summer is very long, this tree may withstand extremes of temperature that are widely removed from anything experienced in the tropics, and other palms generally perfect their fruit wherever they can be grown.

Indeed, so hardy are some of the palms that the question arises whether it may not be possible by selective breeding and adaptation to develop races of palms that will thrive even in the middle latitudes of the eastern United States, and far to the north of their present limits on the Pacific Coast. The fact that most of the palms now growing in California have been introduced within comparatively recent times, and that they have gradually made their way northward, is suggestive of the possibility of much wider extension of their habitat.

A difficulty in the attempt to carry out any project in selective breeding calculated to give the palm additional hardiness or any other quality is found primarily in the fact that this tree does not mature its fruit until from ten to twenty-five years of age. But in recent years an effort is being made by the Department of Agriculture and by several private individuals, to introduce races of date palms that will bear marketable fruit, and the

A Burbank Protege

This palm, now 44 years old, was set out by Mr. Burbank when he first came to Santa Rosa. It is a thrifty specimen, and may be expected to outlive many human generations.

study of the palm that has been undertaken in this connection will doubtless lead to important results. Even now it has been demonstrated that just as good dates can be grown here as in the Sahara.

It appears that the palm, notwithstanding its relative fixity, is subject to considerable variation, and that this is particularly true of the date palm fruit, as might be expected considering that this tree has been under cultivation from pre-historic periods, and because it has been selected for the fruit alone.

The most delicate and delicious date fruits are not the ones that can be secured for export, so that these varieties can never be seen on the American market until they are grown here. All the best date palms, unlike most other palms, are grown from suckers which come up from about the roots of the tree.

To be sure, the Oriental peoples, for whom the date has supplied a most important food product from the earliest periods, have probably paid very little attention to selective breeding. Still the broad general fact that "like produces like" has been matter of common knowledge from remotest antiquity, and it can hardly be doubted that a certain amount of more or less intelligent selection of the trees that bear the best fruit, with attempts to raise seedlings from these trees and thus secure

races of good fruit-bearers, has been practiced, generation after generation.

Moreover a certain amount of cross-pollenizing between allied races of palms has doubtless taken place without the agency of man, and so it is all but certain that the different palms under cultivation bear mixed racial strains, somewhat as do the different races of orchard fruits and cultivated plants of temperate climates.

It is quite to be expected, then, that the palms grown from the seed should show a good deal of variation.

That such is really the case is made obvious to anyone who attempts to raise them. The date palm, for example, may readily enough be grown from the seed, for the seeds germinate readily, though slowly. But the tests have shown that the progeny of a date palm bearing fruit of the best quality cannot be depended upon to transmit the characteristics of the parent with a high degree of certainty.

So it is necessary to grow the young trees from suckers if the strain of the parent is to be perpetuated accurately.

The experts of the Department of Pomology at Washington and several private individuals, have imported rooted suckers, obtained from female trees known to produce fruit of excellent quality,

A Familiar Ampelopsis

There are several species of ampelopsis with which Mr. Burbank has worked extensively. The spray here shown is the familiar Ampelopsis quinquefolia, commonly known as the Virginia Creeper, and sometimes spoken of as the "five-leaved ivy." Mr. Burbank has performed interesting hybridizing experiments with members of the family and has produced some rather important new varieties of crossbred ampelopsis.

distributing them and planting them in various regions of the southwestern United States.

The trees that grew from these suckers have proved to be pistillate, as expected, and produced fruit equal to that of northern Africa. Considerable difficulty was experienced in securing suckers from the best trees, even private individuals not being allowed to own them in the original country. As to the date palm, the progress already made in the improvement of the fruit indicates beyond the shadow of a doubt that still further improvement will be made in many directions. It is probable that the colony of fruit-bearers thus introduced will spread indefinitely, until the date palm becomes an important economic tree in warmer portions of America.

It is even more important with the palm than with other fruit-bearing trees that propagation should be carried out in this way, because when the plants are grown from the seed only half of them will be bearers of pistillate flowers.

The pollen-bearing trees will of course bear no fruit, and while there must be here and there one of these in the palm grove—one pollenate to about twenty-five pistillate trees—it would be an obvious waste of space to give over half the ground to sterile trees. Yet there is no way of determining whether an individual tree is a male or a female

until it comes to the age of blossoming; and the palm is a tree of slow growth that matures only after a good many years.

But trees grown from suckers will be of the same sex as the parent trees; hence the double utility of propagating by this method.

Palms for Ornament

From the standpoint of the present chapter, however, the fruit-bearing qualities of the palm are not so much in question as its ornamental character. Considered merely as ornamental trees, there are members of the genus *Phoenix,* to which the date palm belongs, that are more attractive than this famous fruit bearer. And in general the character of the form and foliage of a date palm is carried with sufficient certainty from parent to offspring by the seed to make it perfectly permissible to raise palms from the seed for ornamental purposes.

Even where the seeds are planted in rows, with the expectation of producing colonnades of palms, along road sides or for borders, the palms may be grown from the seed without danger that they will vary sufficiently to interfere with the symmetry of the row, provided the seed are gathered from the same tree, or at any rate have come from the same region.

If, however, the seed be imported from different

The Bottle-Brush Bush

This is a shrub from New South Wales; a rather tender plant, but thriving out doors at Santa Rosa. It belongs to the myrtle family. See the following picture in explanation of the popular name of this shrub.

regions, there is probability of a good deal of variation even among trees of the same species.

The more usual method, however, in California, is to germinate the seed in a hothouse, growing the young plants in pots at first, and then removing them to boxes that they may be more readily transplanted, as they make slender, wiry roots. They are as easily grown as kernels of corn, though requiring much longer periods of time. Occasionally, however, they are planted in nursery rows, and it is sometimes desirable to transplant them after they have obtained a growth of twenty or thirty feet in height, and a diameter of trunk of one or two feet.

In such a case, it is necessary to cut around the roots of the tree some time before removal, making a ball of earth that is to be removed with the tree. This treatment induces the palm to throw out new roots, giving added firmness, and making provision for the rapid absorption of moisture and nourishment after transplantation.

A box being constructed around the soil, the palm may be removed to any distance.

Sometimes a single palm thus transported is of such size as to require an entire flat car. But unless the precaution is taken to cut back the roots and allow them to stand for some time before removal, as just suggested, there is danger that the

palm will die after transplantation, because the loss of its long roots makes quick adaptation to the new conditions impossible.

The *Phoenix canariensis* is a thoroughly hardy palm in this climate, and the handsomest of the hardy members of the tribe.

It is therefore the one most used for planting for ornament in California, though the *Chamaerops excelsior* from Japan is as hardy and next most common. The Canary palm grows with great rapidity after the plant has the first five or six leaves, although like all other palms its early growth is slow. An ordinary specimen of this species, transplanted into good soil in this region when it has four or five leaves, will grow to a height of fifteen feet, with a corresponding spread of branches, and develop a trunk eighteen inches in diameter in six to ten years.

No other palm with which I am acquainted will make more than about one-fourth this growth in the same time and under the same circumstances.

There is considerable difference in appearance, however, and in rapidity of growth of different strains of palms of this species. Yet the seedlings are unusually true to type, so that long rows of the Canary palms may be grown from the seed with full assurance that they will not vary sufficiently to break up the general uniformity of the row.

Blossom of the Bottle-Brush

A glance shows why this plant has received its popular name. The technical name of the shrub is Callistemon, from a Greek derivative, implying "the flower with beautiful stamens." There are several species of the genous, most of them having flowers with stamens of a beautiful scarlet color. The one here shown is a selected variety of Callistemon lanceolatus.

Palms of the genus *Chamaerops* are also very hardy, perhaps even hardier than the *Phoenix* palms. I have never known one of them to be injured by frost anywhere in California, even when quite young.

There are several species of this genus. I have grown them from the seed somewhat extensively, and have noted a wide variation among different species, some making large trees, while others are dwarfs, some of which, in this region, never attain a height of more than three or four feet. One exceedingly thorny species may be multiplied by division readily, as it throws up suckers abundantly around the old plant, unlike most other palms. Some accidental hybrids have appeared among the species of *Chamaerops*.

Variation and Development

Notwithstanding the considerable variation among the different strains, there is almost no discoverable variation in seedlings of a species of this genus of palm when grown from seed of the same tree. The species most commonly grown in California is *C. Excelsa.* This is a species that in China and Japan is one of the most useful of trees, its foliage being used for thatch, the rigid leaf stalk for braces, and the woolly substance about its trunks for cordage and other purposes.

Moreover this is the palm from which fans are

usually made, the undeveloped, immature leaves being used for this purpose.

The palms of this genus usually bear the stamenate and pistillate flowers on different trees, but it is not unusual to find a few stamenate blossoms on pistillate trees, or, contrariwise, a few pistillate blossoms on stamenate trees. This, however, is a matter of no great practical importance, since the trees are grown in this region only for ornament, and it is not necessary to raise them from the seed, as they put out suckers abundantly.

On the other hand, if the attempt is to be made to hybridize the different species with the hope of developing hardier races, the matter of fertilization of the flowers becomes obviously important.

It will be worth while, then, to select the trees with reference to those that tend to mature their fruit early.

But the work of developing a race of hardy palms will necessarily be a slow one, requiring the co-operative labors of successive generations of plant experimenters. And whereas it is probable that in the course of a century or two hardy palms will be developed, so that the question of selection of ornamental palms will be of interest even to residents of the middle and perhaps even of the northern regions of the United States, at the moment the matter can have practical interest only

Japanese Maple in Mr. Burbank's Yard

This beautiful shrub grows beside Mr. Burbank's own residence in his garden at Santa Rosa. Its qualities as an ornamental shrub, with vine clad walls for a background, are well revealed in this picture. There are several varieties of Japanese maple offering opportunities for cross-breeding experiments.

for a limited number of people, and we need not consider it more at length here.

It suffices to say that the methods of hybridizing and selection that have proved successful with other plants will doubtless be found to have full application to the palm; and to add that the actual work in this field has been begun only in a tentative way.

The method of hybridizing is simplicity itself—as simple as crossing two varieties of corn.

Meantime, however, the palm exists as an ornamental tree of the very greatest value in California, and the interest shown in it by tourists justifies the expectation that in the near future, efforts of a comprehensive character may be made, probably under government supervision, to develop races of palms that can be grown far to the north of the present limits of this tree in the Eastern United States.

A drive along Grange boulevard in Los Angeles, for example, and inspection of its rows of palms, alternating with pepper trees, gives the visitor from the East a mental picture of the possibilities of this race of trees for ornamental purposes that should certainly stimulate a spirit of emulation. Interspersed among pines—their brothers of prehistoric times—they will be particularly appropriate and look especially well.

ON SOME ORNAMENTALS

The ornamental value of palms for roadsides and borders, and artistically placed here and there on the lawn, is admirably supplemented by a background of vines growing on walls or over rustic arbors or pergolas.

And of course there are numerous vines, as everyone is aware, that flourish abundantly in regions where the palm cannot be grown. So the picturesqueness of effect that can be gained by the use of vines sometimes better than in any other way is available for the residents of northern climates, even far toward the arctic circle, almost as fully as in the sub-tropical regions.

Among the vines that are so thrifty that they will grow in almost any soil, and so hardy as to resist the coldest winters, the so-called ivies of the genus *Ampelopsis* take foremost rank. Of these the Japanese Ivy, sometimes known as Boston Ivy (*A. vitchi*) and its varieties, is probably the best known and the most extensively grown. For the purpose of covering brick and stone walls it is perhaps the most beautiful of all vines.

This vine has a close rival, however, and in the opinion of some even a superior, in the native species familiar everywhere in the middle and eastern states as the Five-Leafed Ivy or Virginia Creeper. This vine, however, does not cling to flat, smooth surfaces as does the Asiatic species.

The strains of this vine differ materially in different localities, there being one in particular, named the *Engelmanni,* which clings to walls and trees better than the ordinary varieties. Vines of this variety are also far ahead of others in their rapidity of growth and in the beauty of their foliage, and especially in their autumn coloring. Some varieties hold their foliage nearly a month longer than others.

These variations should be borne in mind in selecting plants for the covering of walls or making of arbors. The vines growing wild in Colorado are, in my opinion, much superior to those of the eastern states.

I have raised thousands of seedlings of both species of *Ampelopsis* just named, and many specimens of other species known respectively as *A. heterophyla* and *A. arborea,* and have attempted to hybridize them, but only recently succeeded.

The Japanese Ivy and the Virginia Creeper have now been crossed by me, and it is expected that the combination will produce varieties of priceless value, giving opportunity for the development of new races or ornamental vines to add to the comparatively limited number now available. The work is being carried forward on a large scale. It is probable that the *Ampelopsis* and the grape may be brought into combination.

Leaves of a Japanese Maple

This variety of Japanese maple is prized for the color of the leaves,—and very justly so. There are other varieties, however, in which the leaves are curiously reticulate, some of them giving the appearance of leaves that have been dissected so that only the ribs remain. It would be of great interest to cross maples of these two types, noting the results in the first and second generations.

Meantime, I have developed a new variety of Virginia Creeper through selection that has much larger foliage than the ordinary varieties, and that is also a much more rapid grower, with the habit of holding the foliage to a late period in the autumn. As the plant is readily propagated by cuttings, such a new race as this may be distributed indefinitely.

The Beautiful Clematis

These vines are grown chiefly for their beauty of foliage alone, although the grape-like berries of the Virginia Creeper are not without some decorative value.

There are other vines that in some respects rival the *Ampelopsis* as climbers for the covering of walls and arbors, and that have the added merit of producing beautiful flowers. Notable among the vines that have this double attractiveness are the various species of Clematis.

There are several native species of the Clematis, and the plant has been brought sufficiently under cultivation to develop a propensity to vary. Nearly all the species are rapid climbers, and produce beautiful flowers in astonishing abundance. In addition some have feathery seed-pods that are scarcely less attractive and interesting than the blossoms that precede them, making an artistic contrast with the foliage for a considerable period.

So all in all the clematis must be ranked among the most beautiful of vines.

My work with the members of this tribe has been largely with the types that are known horticulturally as *Jackmanni lanuginosa.* These have large blue and white flowers, sometimes inclined to red and pink.

I have raised these plants very extensively from the seed for many years. By selection, several varieties were produced that bore very handsome double flowers of peculiar form, varying in color from blue, pink, and ashy gray to pure white. Some of the new varieties also have exceedingly large broad petals with the flowers of unusually rounded outline, not unlike the form of a dahlia.

Several of the best varieties of these improved Clematis vines were introduced through a dealer. But it was subsequently related that the clematis disease had destroyed most of these. This disease is a kind of rot, usually ascribed to the same cause that destroys lilies and many other plants in cultivated soil. It is probably bacterial, and is always associated with thrips, millipeds, and eel-worms, which probably serve to disseminate the germs.

Subsequently I began a series of hybridizing experiments, using the *Clematis coccinea* as the original seed parent.

This species is herbaceous and has scarlet,

"The Summer Lilac"

***This is a shrub** known to the botanist as Buddleia variabilis. **There are many species of the genous, but not very many are under cultivation.** The one here shown **was introduced from** China. It has fragrant **flowers which, as will be** seen, are borne in profusion.*

flask-shaped flowers, with the sepals slightly opened by the curling outward of their tips. The sepals are thick and fleshy, although not leathery, giving the flower almost the appearance of a fruit.

This species is almost invariable, about the only diversity noticeable being a slight variation in the size of the flowers.

To the pistils of several specimens of *coccinea* was applied the pollen of various other species; among these being *C. crispa,* known as "Blue Bells", *C. Davidiana, C. Fremonti, C. ligusticifolia, C. Bouglasi, C. verticillaris, C. occidentalis, C. Fortunei, C. Viticella,* and others, no attempt being made to keep the various crosses separate.

The hybrid progeny showed a great amount of variation, especially as regards color of the flowers. There were blue, crimson, scarlet, and white flowers, and sometimes all of these colors appeared in a single blossom.

There was also much variation within certain limits in the form and texture of the flowers, which in general were of a larger size than those of the seed parent, and more spreading and widely open in form. Some had thick sepals and some had thin ones.

Perhaps the most striking peculiarity was that the interior of the sepals often had a frosted appearance, due to the presence of a filament net-

work of papillae. There is something of this appearance occasionally in flowers of *C. coccinea* and *C. crispa,* but it was much accentuated in many of the hybrids.

In their general habit and their herbaceous stems, the hybrids seem uniformly to follow the seed parent.

The flowers were produced in great abundance, and the colors were not only most beautiful but showed combinations never before seen in the clematis. The bell-shaped flowers are for the most part white on the inside, but exteriorly they are crimson, pink, orange, blue, or purple. The beautiful frosty throats give the flowers an appearance that is unique.

I selected among the hybrids a few of the most beautiful forms, and placed these, without specific names, with a florist, Mr. J. C. Vaughan of Chicago, for introduction. Some of my earlier clematis introductions had been given names more or less suggestive of their peculiarities of flower, including "Ostrich Plume" and "Snow Drift". Another had been named "Waverley".

I have stated that the earlier varieties were destroyed by the clematis disease. In the later experiments I endeavored to produce varieties that would be immune to disease, as well as those that would show exceptional hardiness.

ON SOME ORNAMENTALS

Several years ago, while on a trip in northern Canada, I found patches of clematis on half-woody slopes, growing in a region where the thermometer sometimes goes fifty or even sixty degrees below zero in the winter—regions where the deep wells do not thaw out altogether during the entire summer, always having a coating of ice about their walls.

The hardy clematis found in this region bears dark blue flowers that are fully three and a half inches in diameter, being about as large as those of the cultivated varieties known as the blue Jackmanni, the blossoms of which they also resemble in color. There are two or three wild species in the same regions, namely *C. Fremonti* and *C. ligusticifolia,* plants that bear rather inconspicuous flowers of a greenish white color, but having long, feathery seed coverings that give them interest, and being in addition strong growers.

I have already named these among the species of clematis that were used in hybridizing experiments.

It was to be expected that plants having strains of such hardy species in their heredity would develop some varieties of great hardiness. And in this the expectations were not disappointed. A more extended series of experiments than I had planned to undertake would be necessary to fix

the new varieties, and to make sure as to which of them are the hardiest.

There is still opportunity for fine work in this direction. The clematis is so beautiful a vine, and there are so many species available, and among these species such amazing variety of form of vine and flower, that the opportunity for extensive breeding experiments with this type is most inviting.

In raising the seedlings my practice was to sow the seed quite thickly in boxes in the greenhouse, as soon as it ripened in the fall, forcing the plants throughout the winter, and transplanting them in the open field in the early spring. The seedlings would make vines from eighteen inches to two feet long the first season. They would rarely bloom the first year, but in the second season they would almost invariably do so and the general character of their flowers could then be determined.

But the blossoms of the first season would not fully represent the possibilities of their mature production. For example, plants that first bear blossoms that are semi-double would in later seasons, when the vines had gained in strength, bear fully double flowers.

At the time when my first hybrid double clematis flowers were produced, there was, I think, but one other double one known anywhere in the

Flowers of the Tecoma

There are more than one hundred species of this genous, natives of temperate, tropical, and subtropical America, and also of Asia and Africa. Owing to the shape of the flowers, they are popularly known as trumpet vines. Some species, however, are upright shrubs or trees. Mr. Burbank has hybridized several of the Tecomas with the Bignonia.

world, this being a form produced in England. More recently, however, several good double varieties of this class have been introduced.

The clematis is a plant that improves with acquaintance. Existing varieties furnish vines that are beautiful in foliage, in flower, and in their picturesque display of seed-pods. There is a great variation among the forms already under cultivation, but there is still abundant opportunity for improvement with these; and in addition wild species may be found that through hybridization will certainly introduce tendencies to still wider variation.

What plant could offer greater inducements to the would-be experimenter?

Bignonia, Wistaria, and Bell-Flower

Of the numerous other interesting ornamental vines with which I have worked more or less extensively, I must content myself with mention of only two or three. Not that there is lack of interest, but to detail my work with them would involve a needless repetition as to methods. The work with the clematis may be taken as typical, and as representing one of my most extensive single series of experiments in connection with the ornamental vines.

There are two or three other groups of vines, however, that must be given at least passing notice.

ON SOME ORNAMENTALS

One of the interesting forms with which I have done a good deal of work is the tribe of climbing shrubby plants of North and South America of the genus *Bignonia*. I have hybridized some species of bignonia with several of the *Tecoma*, a plant that grows wild in Virginia and Maryland.

The resulting vines were variable, and had a fair degree of interest. There was modification of color of flower, length of seed-pods, and vigor of growth of the plants themselves. But no variety was secured that seemed worthy of introduction.

An interesting feature of the hybridizing experiments with the bignonia is associated with the curious sensitiveness of the stigma of the flower to irritation. The two lips of the stigma stand open, like a set trap, and when pollen is supplied they close, trap-like, grasping it instantly. Anyone who has never seen the lips of the stigma of the bignonia close when irritated by bees or artificial means would be greatly surprised.

It is necessary in applying the pollen to be somewhat dexterous, lest the lips of the stigma close and make the stigmatic surface inaccessible.

Nor may the lips be pried apart. They open spontaneously, however, after a time, but usually not until the patience of the operator has been exhausted. It is a curious and interesting experiment to irritate the stigmatic surface with a grass

The Golden Chile Sisyrinchium

These flowers belong to the iris family. There are about sixty species, including those popularly known as the satin flower, blue-eyed grass, and rusk lily. Mr. Burbank has experimented with this beautiful South American species, which makes an admirable border flower.

stem or twig, which will be grasped as the trap-like stigma closes, and held as a frog might hold a stick in its mouth. The same remarks apply also to the unrelated mulus, or monkey flower.

Good work may be done by crossing the hardy bignonia with the tender ones, with excellent prospect of producing new varieties of value.

Another ornamental vine that offers good opportunities for the plant developer is the familiar and beautiful Wistaria.

There is a fair degree of variation among the different species of wistaria, some bearing blue flowers and others white ones. The plants of this genus are not only valuable as climbers, covering walls and arbors with vines that bear beautiful flowers, but they can also be trained to form tree-like bushes that are most attractive additions to the lawn. The Chinese wistaria is ordinarily a long vine, but may be trained to a bush five feet across and thrive fully as well. Under this mode of culture, a certain amount of energy that would ordinarily go to the production of the vine itself is saved and utilized for flower production, so that wistaria bushes thus trained become astonishing bearers of blossoms, like gigantic bouquets.

Nothing more is necessary in training the vine than to trim it to form a head, and then from time to time to cut out the straggling branches.

The wisterias are difficult to hybridize, because their flowers are papillionaceous, like those of the peas and beans. But with a little care, hand-pollenation may be effected, and some very striking variations should be obtained in the second generation from a cross, for example, between the American and Chinese wistarias.

A complex hybrid between these species and the Japanese variety, *Wistaria multiguga,* which produces astonishingly long racemes of flowers, should give results of additional interest.

My own experiments with the wistarias have consisted of the growing of a great number of seedlings, both of the Chinese and American species, selecting among these for plants varying in form, and bearing blossoms of different size and colors. The results of these experiments show that the wistaria is an adaptable flower, and one that is almost certain to repay more extensive breeding experiments, in particular those that introduce the element of hybridization.

I will name only one other type of ornamental vines, this being the *Lapageria,* or Chilean Bell-Flower.

As an excuse for selecting this one among many tropical and sub-tropical forms, I may say that when I first saw the Chilean bell-flower I thought it the most beautiful flower of any kind that I had

The Clematis

There are several species of this popular vine and Mr. Burbank has made very remarkable crossbreeding experiments with them, producing some interesting varieties that were introduced a good many years ago. Few ornamental vines better merit the attention of the amateur than the clematis.

ever seen. It has glorious, great, drooping, bell-shaped, rosy or white blossoms, which no lover of flowers could fail to admire. The foliage of the plant is smilax-like, and somewhat deficient in quantity, but the wonderful flowers make amends for any defect of foliage.

Unfortunately the plants are very difficult to raise, needing peculiar soil and much attention. They are also sensitive to changes of temperature, and do not bloom at an early age. Moreover they must be kept moist at all times to insure good growth.

The possibilities of work with plants of this genus are shown in a remarkable cross said to have been made by Veitch between one of the *Lapagerias* and the *Philesia buxifolia,* the latter being the pollen plant. The hybrid which has been named *Philegeria Veitchii,* is of exceptional interest, inasmuch as the parents belong to different genera. In scientific interest it ranks with the blackberry-raspberry hybrids, and the cross between the amaryllis plants and their remote relatives.

As illustrating the possibility of the production of interesting new forms, I may note that a collector in Chile sent me a few years ago several species of plants allied to the *Lapageria,* but unclassified as to species, that very much resemble the English Ivy and that show exceptional habits

of growth. One of these is said to bear excellent fruit.

At three years of age, when the first blossoms appeared, the strongest plants were about fifteen feet high. Among the thousands of seedlings, there is enough difference in the form of foliage, rapidity of growth, and other characteristics to show that the plant is susceptible of improvement even in the first generation of seedlings from wild stock

Experiments in hybridizing these new plants with *Lapageria,* and further experiments in selection, in the hope of securing a new vine that combines with other good qualities the property of fruit-production, are contemplated. As yet this series of experiments is only at its beginning, but I mention it as illustrating one of the many lines of investigation, looking to the development of new varieties of ornamental vines, that invite the experimenter.

—The clematis is a plant that improves with acquaintance. There is a great variety among the forms already under cultivation and through hybridization with wild species, still greater variation may be induced.

The Lippia

This is one of the plants that Mr. Burbank is testing as a substitute for lawn grass. The species here shown is known as Lippia repens. It will be seen that the plant makes a highly attractive lawn cover in blossoming time. At other seasons it is a mass of green that is a very good substitute for bluegrass.

Lawns and Their Beautification

Some Old and New Shrubs and Grasses

PERSONS who have visited me at Santa Rosa in recent years are almost always greatly interested in the lawn about my dwelling. At a little distance this looks very much like any other lawn that is well-covered with grass. But on closer inspection it appears that the lawn is carpeted with a plant that is obviously not a grass. It is in reality a species of verbena, very much more closely related to the familiar flower of that name than any other plant in cultivation.

This anomalous substitute for lawn grass is a plant which was briefly referred to in an earlier chapter as a relative of the verbena. It is known as *Lippia repens,* and by some European botanists classified as *Lippia canescens.* It is a plant indigenous to Chile, from which country I received the seed from which the new lawn plant was developed a number of years ago.

The value of the Lippias as lawn plants had been shown by Dr. Francheschi, of Santa Barbara, California, as long ago as 1900, he having introduced a common form of *Lippia repens* from Southern Europe where it had been grown as a lawn plant by division until it lost its power of producing seed, thus making further improvement impossible.

The opportunity to improve the plant came when my collector in Chile sent me seed of some of the wild species. I saw that there was a good deal of variation among the plants raised from this seed, and in the following season raised about ten thousand plants, each one of which was given a little space in order that its individual peculiarities as to rapidity of growth, tendency to spread, and color of foliage might be studied.

From among some ten thousand plants about half a dozen were saved, and the descendants of these constitute several varieties of Lippias that have marked peculiarities. A single cutting of one variety will spread on an ordinary soil over a circle about ten feet in diameter, in a single season. This form would be very valuable for growing in sunny places, in certain localities along irrigating ditches, where the soil is subject to wash.

But I have more recently found two far better substitutes for this purpose. One is the *Mesam-*

bryanthemum, which grows on all seacoasts. This produces an enormous amount of very heavy foliage, which is not moved even by a strong stream of water.

The other is the vine commonly called the trailing myrtle (*Vinca minor*). This forms a great mass of long white roots and long-topped vines with abundant evergreen foliage, which resists stream wash by shingling the whole surface so that the water cannot reach the soil.

Another variety of seedling lippia grows only half as fast, but has very fine dark green leaves and lies very close to the ground, making a most beautiful velvety lawn, while the older lippias made a very unsightly lawn, though valuable for dry climates. Unfortunately none are hardy in the cold northern climates.

A third variety of lippia has pale green leaves, is a slower and more compact grower, and makes a lawn that contracts charmingly in color with a lawn of the other lippias, or ordinary lawns of bluegrass.

A fourth variety has long rope-like runners growing in all directions, but not filling up the spaces, and therefore not being suitable for lawns. Still another has hairy leaves that give it a peculiar frosty appearance, whereas the leaves of other varieties are most often glossy.

The foliage of these selected new seedlings vary greatly in size, the leaves of some being several times as large as others. The half dozen types selected are being used for further development, and as might be expected they show still more astonishing variations in the second generation. A single plant of some of the rapid growing varities usually overgrows and covers up perhaps a dozen of the smaller lippias of the same age.

Add that the new plants, in addition to their rapid and compact growth, are adapted to dry soil, requiring not one-tenth the water that blue-grass or other ordinary lawn grass requires, and keeping in good condition longer than any bluegrass or clover lawn with a fraction of the care or the expense for watering, weeding, and mowing necessitated by the ordinary lawn, and it is obvious that the developed variaties of lippias constitute a very important acquisition.

Curiously enough the lippia lawn makes a better appearance where it is frequently trod upon and subjected to treatment that would injure an ordinary grass lawn, or destroy it altogether. The plants appear to pay no attention if a path is made directly over them; their appearance is actually improved thereby.

With some species occasional runners may grow above the main mass of foliage and become

Spanish Broom Bush

This compact, upright, ornamental shrub, is known to the botanist as Spartium junceum. It is a thrifty shrub, but unfortunately not very hardy. In any region where it can be grown, it should be prized as a garden ornament. Mr. Burbank has developed the plant by selective breeding.

unsightly, but these are readily cut away, leaving a smooth velvety surface. These long runners could be wholly prevented by cutting through the plant diagonally at intervals of about two inches with a machine similar to a strawberry runner cutter, but with several blades.

The real difficulty that stands in the way of the general introduction of the lippias as lawn plants of altogether exceptional quality, however, is their relative tenderness to frost. If selections result in producing a hardy lippia, the plant will be welcomed everywhere, as it is already coming to be welcomed in the warmer regions as one that solves the problem of a lawn that will require practically no attention, and yet maintain its greenness even in long periods of summer drought. It must be added, however, that during the wintertime it turns brownish, and at that season it is not quite as ornamental as a bluegrass lawn.

Until the lippia is further developed for hardiness, however, it could not be used except in the milder climates, and in the cold regions the bluegrass and other allied grasses and the clovers must be depended on for making lawns.

Meantime there are two of the new varieties of lippias that have been introduced, and that are rapidly making their way in California. One of these, named Dixie, makes a most beautiful dark-

green, close-growing lawn. The other, named Mojave, has light-green foliage, in color not unlike that of the older lippias, but is a larger and far more rapid grower. This form is particularly valuable for quickly covering banks that are subject to erosion from streams or heavy rainfall. It rapidly makes an impenetrable mat that resists the invasion of water most persistently.

With all their tenacity in resisting storms, drought, and constant tramping, these lippias do not become weeds, as they produce no underground stolons. By simple plowing or spading they may be more readily removed than the ordinary lawn grass.

If left all summer without mowing, the lippia lawn makes a rich bee pasture resembling some of the handsome low growing clovers. If mown once or twice it has the general appearance of a bluegrass lawn, being soft and yielding to the tread like a fine Axminster carpet. The lippias do not thrive so well in the shade, being essentially sun lovers. They turn brown during a few weeks in winter. The two new lippias just described settle the lawn question for sunny places in warm climates, as well as the problem of very greatly lessening the wasting of land by erosion on river banks and hillsides.

Meantime other experiments are being carried on with various other plants which give promise of

finally making good lawn plants. Among the most interesting is a species of trailing *Hypericum*, specific name unknown, from the mountains of eastern Chile. As my lawn is an experimental one, this has now supplanted the lippias there, and as the new plant does not at any time turn brown in the winter, like the lippias, it may prove superior in beauty, though not quite as rapid in covering a lawn surface.

Somewhat similar species of hypericum have lately been introduced in my gardens from Russian Siberia, and central and northern Europe, which show a similar creeping habit, and no doubt will be hardy everywhere. These, even in the first generation from the wild native parent, show a wonderful variation in rapidity and compactness of growth, and from all appearance a few years' work will give us a lawn plant for all climates far superior to anything hitherto known, but probably a little more difficult to get started.

All the hypericums will stand a great amount of drought and ill treatment; they are unusually hardy, stand tramping and mowing readily. No doubt in future there will be produced varieties that will be exceedingly valuable as lawn plants for all climates.

Until the new plants have been perfected, however, the conventional lawn grass, with blue-grass

Alfalfa Seed

At the left, pure seed of the alfalfa; at the right, alfalfa seed mixed with foreign seed, as it is often found in the market. Alfalfa is a rather difficult crop to start, and it is obviously desirable that pure seed should be used. Once the plant has become well rooted, it will hold its own against all invaders.

at the head of the list, must be relied on in colder climates. It is not necessary to refer to the common lawn grasses here in detail, their general character and qualities being familiar to everyone, and there having been no marked development in recent years in the way of improving them.

It suffices to suggest that care should be taken in buying seed from reputable dealers that grass of good quality may be secured and the number of weeds minimized. Beyond that it is hardly to be expected that the interests of the amateur plant developer will extend. For the grasses do not offer opportunities for striking results in the way of improvement that make them appeal to the amateur. And, in any event, the blue-grass in its best varieties constitutes a lawn grass of really fine quality, and if properly cared for will produce a lawn of a very satisfactory character. Mixtures are never better, and seldom as good as the pure Kentucky blue-grass lawn.

As to the matter of soil for the lawn, nothing specific need be said beyond the statement that the same sort of preparation is desirable that would be used in preparing soil for field or garden crops. Some details as to this will be given in the succeeding chapter.

But I should like to offer a few practical hints as to such preparation of the lawn as will ensure a

proper regulation of the supply of air and water, upon which the condition of the lawn so largely depends. What is true about drainage and irrigation will have equal application to land that is to be used for raising flowers or vegetables or small fruits. Indeed, my suggestions are based very largely on my personal experience at Santa Rosa in preparing the ground for the experiment gardens on which plants of several thousand different species, and representing many families from all parts of the globe are grown.

A Practical Drainage System

Many hundreds of persons visiting my experiment grounds at Santa Rosa each season have marvelled at the exceedingly varied and prolific crops raised—exclaiming, "What a delightful soil you have!"

Their surprise grows when they are assured that this productive land was originally almost valueless for growing plants. It was made fruitful by artificial drainage and irrigation. The application of the simplest principles of regulation of water supply resulted in transforming a relatively sterile soil into one of the most fertile areas of the earth's surface. The method in which this was accomplished may be outlined as offering a model that may be followed to advantage in draining similar land anywhere.

Probably half the low-lying soils in the United States could be made more productive by drainage. Even if the soil of your lawns and gardens is fairly productive, you may advantageously consider the advisability of introducing such a system of drainage as that which we have employed at Santa Rosa with such striking results.

The soil consisted of what is called adobe, a black clay-like soil, said to be of volcanic origin, and this particular piece cracked so during the latter part of the dry season, that it was considered unsafe to pasture stock on it, as it endangered the legs of the animals, the cracks being often several inches in width and apparently bottomless. No crop had been grown here for years; and house lots a mile or more out sold for about the price I paid for the four acres.

Of course there is nothing novel about the statement that the drainage of land is important. The matter has been more or less understood since the earliest periods. Yet a very large part of the land of the United States that is given over to lawns and gardens is left to depend entirely on natural drainage, and fails to produce anything like the crops that might be grown on it, if a more rational provision had been made for adjusting the water supply.

In California the value of drainage has been

Bouquet of Campion Flowers

This pleasing flower has been grown by Mr. Burbank and improved by careful selection. The plant is hardy and prolific, and there are numerous other species with some of which hybridization might doubtless be effected.

shown in the results obtained even with wheat on fields drained and those not drained. Only one or two ditches across a field have made it possible to produce two or three times as large a crop as was grown in the same field before the ditches were made.

In a certain oat field in Wisconsin, the yield per acre was doubled by drainage. The yield before drainage was only sixteen bushels, but after drainage it increased to 32.3 bushels per acre.

There are at least two bad effects to be expected from an oversupply of water. They are:

(1) An oversupply makes certain areas so soft that they cannot be cultivated at all or at least not until late in the spring.

(2) Air, which is essential to plant growth, cannot enter the soil supplied with a superabundance of water.

Air is as necessary to the roots of plants as water and it is upon this principle that all systems of cultivation and drainage are based.

The complicated chemical changes in the growth of the plant cannot take place unless there is sufficient of both air and water. Roots cannot exist where there is a superabundance of water in the soil.

There are several systems of drainage which will not be discussed here. I consider underdrain-

age with common drain tile the best system for ordinary conditions, and it is with this system that I have had most experience. The discussion is given mostly from the viewpoint of results on my own grounds.

Small, well-burned drain tile was used on my Santa Rosa ground carefully laid with a slope of 1 foot to 40 feet and it has proven eminently satisfactory in every respect for twenty years. The soil is a heavy adobe and was almost worthless before it was drained.

The good results of the drainage were scarcely apparent the first year, but the benefits were multiplied each year until now the soil is easily cultivated and bears enormous crops while before draining no crop could be raised.

This system consists of one main line of 4-inch tile with laterals of two-inch tile every 40 feet. The laterals gather the surplus water quickly after a heavy rain and the main tile carries it to a small stream near by.

The laterals do not need such a large capacity as most people think. It must be remembered that they work both day and night, and Sundays as well as week days and a very small tile will carry a great amount of water in the course of twenty-four hours.

It is a good plan to have the tiles flushed now

The Hydrangia

The hydrangia is a shrub of deserved popularity in almost every garden. Mr. Burbank has experimented with the plant somewhat extensively, in the way of selective breeding. The picture shows one of his newest varieties.

and then, and if they are not too large they will sometimes be flushed during heavy rains when they are filled to capacity. This flushing serves to keep them clean and the flushing produced naturally when small tiles are used is sufficient reason for recommending the smaller sizes rather than larger ones which are more expensive and generally less efficient.

The general impression is that cracks should be left, and sand put in the cracks. The real way is to surround the joints with clay; then they are permanent. The *worst* thing to do is to put sand or gravel or straw about the cracks. A tile four feet deep will drain twice as wide an area as a tile two feet deep. About four feet is the proper depth.

The strength of the entire system depends upon the weakest section. Therefore it is necessary in laying the tile to examine carefully each piece, and to see that they are well burned, but not sufficiently to make them impervious. The system must be laid upon the proper grade, for if the line sags, sediment will collect and retard the flow of water.

It is best to make a silt basin at some point where the branching tiles unite. This is formed by digging down a foot or two, and bricking or cementing up a barrel-like receptacle, the entrance pipe from the main system being a little lower than the exit pipe, so that the silt settles.

In the twenty years since the tile system was laid at Santa Rosa, the tile itself has never been exposed, or in any way touched or examined. It continues to perform its function perfectly.

Drainage is really a science in itself, and there is not enough space here to give a full discussion of it. There are a number of good books upon the subject, however, and the names of these will be found in the chapter on reference literature.

Before the system is installed, some complete treatise on drainage should be thoroughly studied.

In some cases it is possible to secure the aid of a person who has had experience in laying drain tiles, and where this is possible it is the best plan.

Supplying Water

Irrigation is closely allied to drainage. The two systems are for a similar purpose—to regulate the amount of moisture in the soil for plant growth.

Irrigation is needed in locations where there is not sufficient rainfall to insure the growth of certain crops. In many places also where the rainfall is sufficient but not well distributed, irrigation will be profitable, especially in seasons of unusual drouth.

For large tracts such as orchards and extensive seed and vegetable gardens, the common practice is to run water in large ditches with a system of smaller ditches throughout the field.

If such a system is properly constructed and cared for, little is wasted because it is placed very close to the point where it is needed.

For small areas, sprinklers are generally used.

The fault with most of the common sprinklers used to irrigate small areas, such as lawns and small gardens is that they do not distribute the water evenly. Most of them cover a circular space and there is always some part of the soil which has too much water or too little. One of the most important points in irrigation is to have the water distributed evenly.

Some flat or fish-tail sprinklers distribute water quite evenly, but the newer system of overhead irrigation known as the Skinner system is, in my judgment, by far the best for small areas, and possibly for all areas of any size.

This consists of a number of one-inch galvanized pipes with nipples placed along the sides about 12 to 20 inches apart. These pipes with the nipples inserted are mounted upon supports about 6 feet above the ground. The pipes are connected with the water supply and the water turned on when needed.

Depending upon the pressure, this system will distribute water evenly for a space of from 25 to 50 feet on either side of the pipe. The pipe may be located between two beds so that it may be turned

A South American Flower

This strange flower with its unusual markings, was grown from seed sent to Mr. Burbank by a South American missionary. It is one of many such which have encouraged Mr. Burbank to further experiments toward improvement.

on its support and distribute the water on either side. When advantage can be taken of the wind, the water will be thrown almost twice as far as when there is no wind.

This system has been somewhat modified to adapt it to small areas where irrigation is not needed often. Instead of mounting the pipes upon permanent stakes, they are carried from one place to another as irrigation is needed and placed upon temporary supports or movable stands.

For greater convenience in handling the pipes, the temporary supports are only about 4 feet high. On the top of these is nailed a curved piece of sheet iron in which the pipe rests. The movable stands are made of galvanized pipe in tripod form and can be made by any plumber.

The sprinkler pipe is attached to the water supply by a rubber hose and the system operates in the same way as when in a permanent location.

This system is patented but it is not expensive to install. The pipes can be purchased at any hardware store but the nipples and the tool for drilling the holes in the pipe for the nipples are patented and must be purchased separately. Many of the seed houses, that handle tools in addition to seeds, sell this irrigating system.

When this system is to be used on a lawn the supports can be made more or less ornamental.

The cost of irrigating lawns by this method is far less than by the use of circular sprinklers, for both time and water are saved and the lawn is supplied with a more even distribution of moisture.

There is another plan of irrigation which is known as the underground pipe or tile system. This is not often used because the first cost is too great. In some cases, however, it has proven to be satisfactory.

The part of any sprinkler system that deteriorates most rapidly is the rubber hose. When it can be replaced by iron pipe it should always be done to save expense.

Where hose is used it is usually necessary to purchase a new supply each season. Its first cost is two or three times more than that of a galvanized iron pipe and the pipe usually lasts from ten to fifteen years. There are several other systems of irrigation of lesser importance, but it is not necessary to describe them here.

The Menace of Weeds

However well the soil may be prepared for garden or lawn, and whatever the attention given, the cultivated plants of every description are perpetually menaced by the rivalry of weeds.

A weed may be said to be a plant out of its proper place so far as the economy of man is concerned.

This does not mean, however, that it is out of its proper place in the economy of Nature. Nature has a use for weeds and in fact they have done much good for man.

When crops were first cultivated, farmers stirred the soil in order to destroy the weeds. They did not then fully realize that stirring the soil aided the growth of the crops. They did discover, however, that when the weeds were destroyed much better crops were produced, and thus the weeds forced farmers to stir the soil and allow the air, so necessary to the plants, to circulate among the roots.

Now that the farmers have learned the real reason for cultivation at the proper times, whether there are weeds present or not, the destruction of weeds assumes a different aspect.

Weeds are a detriment in many cases from the fact that when proper precautions are not used they take possession of areas of land so that it is impossible to grow useful crops.

There are two general classes of weeds, annuals and perennials.

Annual weeds reproduce themselves by seeds which mature each season, usually in great abundance. Perennials, in cold climates, although most of them produce seeds, also perpetuate themselves by storing food and living matter under the ground

where the life of the plant is protected until spring. Many perennials have underground stems which are sent out in all directions. From each node a new plant may grow under the proper conditions.

It is obvious that such weeds are most difficult to destroy because, although they may be prevented from bearing seeds, they distribute themselves over large areas.

The handling of annual weeds is summed up briefly in one sentence: Prevent the production and the introduction of seeds.

But with perennials not only must the introduction and production of seeds be prevented, but the entire plant must be uprooted and destroyed.

When perennial weeds have taken possession of an area of land, they may generally be brought under control by thorough cultivation during one or two seasons. This often means that one or more crops must be sacrificed. Every weed on the entire area must be destroyed as soon as—and with some kinds before—it appears above the surface.

The vitality and food provided by perennials in most cases does not keep the plant alive more than one season. The plant depends upon its store of food being replenished by another growth each season. If the leaves cannot develop above the ground, so that raw food collected by the roots

can be digested and stored again underground, the plant cannot grow the following season.

Thus it is that by cutting off the plants continually for an entire season as soon as they appear above ground they will die out and not appear again on that area unless, of course, the seeds are again introduced.

Most weeds are provided with greater facilities for reproduction and distribution than cultivated plants. Most weeds also have some special means for distributing their seeds over large areas.

Many of them, such as cockleburs (*Xanthium*), sandburs (*Cenchrus*), burdock (*Arctium*) and stick-tights (*Bidens*), have burrs surrounding each seed which are made up usually of many hooks or spines. These seeds attach themselves to the clothing of persons and to the various domestic animals, and are thus transferred from one locality to another.

Many of the weed seeds such as the thistles, wild lettuce, dandelions, etc., are provided with a feathery portion which assists their carriage by the wind.

Other seeds are borne in pods which, when dry, open with a suddenness which throws the seeds great distances.

Some seeds are borne in fruits which are relished by birds and animals. The seeds in this

South American Grass

This is an unnamed grass from South America, which has interest because of the curious panicles (suggesting plumes of a bird of paradise), in which its seeds are grown. This is one of a great number of grasses with which Mr. Burbank has experimented.

case are usually small and are provided with a hard coating so that they are not destroyed by digestion in the bird's or animal's stomach, but are carried great distances and on reaching the ground are usually in best condition to germinate.

Most weed seeds have the ability to retain their vitality for a long time. Farmers who have plowed fields deeply have sometimes noticed that a certain weed which was present the year before plowing disappeared entirely for two or three years only to reappear again later. This was due to the fact that the seeds were placed by the deep plowing several inches below the surface, and when the soil was plowed deep again they were brought nearer the surface. In some cases, seeds have been known to retain their vitality for twenty years or more.

Although weed seeds are provided with many more contrivances to secure a wide distribution than those here mentioned, this is not the only provision for their perpetuation. Living as they do among many discouragements and difficulties it has been necessary for them to provide protection for the plants themselves against unfavorable weather conditions and against animals. Some weeds have the ability to withstand long and severe drouths while others are able to grow where there is a superabundance of moisture. Some are able to withstand extremely low temperatures.

Protection against destruction by animals is afforded by spines, thorns, bitter juices, and poisons.

Understanding these provisions of Nature for the production and perpetuation of weeds it is quite apparent that prompt and efficient methods must be used by farmers and gardners in destroying them on first appearance.

A few mustard, thistle, or dandelion plants which seem harmless because there are so few, may spread to such an extent that in a few years it will cost thousands of dollars to rid an infested area from the pest which, if destroyed while still few in numbers, would have cost only a few dollars or dimes.

Weeds are much like a leak in a boiler or a fire let loose. They are easily attended to at first, but lead to destruction if proper attention is not given in the beginning. Never is the old saying "A stitch in time saves nine" better exemplified than in the case of weeds.

As has already been intimated, many fields are infested with weeds through the introduction of the seeds in the seeding of the crops to be grown. Weeds that thrive particularly well with certain crops sometimes produce seeds so like the seeds of the crop in size and appearance that it is often practically impossible to separate them.

In many sections a weed known as corn cockle (*Agrostemma*) is a pest in wheat fields. So nearly do the seeds of the corn cockle resemble the kernels of wheat in weight and size that for a long time it was almost impossible to separate the cockle seeds from the wheat. This, of course, caused millers a great deal of trouble for the corn cockle seeds have a black shell about them which discolors the flour. Finally a special machine was constructed for the removal of cockle seeds.

The perennial morning-glory, commonly called the devil's shoe string, has often palmed seeds off for wheat among screenings fed to poultry, being about the same size and has established itself on much of the best soils in California.

The darnel (*Lolium*) commonly called cheat, infests grain fields in some sections and so well have the seeds masqueraded that many farmers thinking their seed was thoroughly clean, later found this weed and have said that the seeds changed into wheat, barley, oats, or whatever the grain happened to be.

This mimicry, of course, is developed by evolution. That is, those seeds which are most nearly like the seeds with which they are mixed are overlooked in cleaning and remain to perpetuate the race. After many generations of this sort of natural selection, the seeds constantly

approach the grain seed in form, size, weight and color.

The seeds do not change their botanical characters as farmers suppose, but having a hard coat, may lie in the ground until a wet season when the grain is destroyed and the darnel takes its place.

Many states have long maintained official seed inspection for purity. Now there is a United States law of similar nature. These laws have been so well enforced that there is not so much danger now of infesting land with weed seeds as was the case a few years ago.

Farmers who make a practice of buying grain for seed from their neighbors or other persons who have not had their seeds examined by inspectors are likely to have their fields infested with noxious weeds. From a small sample, the quantity and kinds of weed seeds may be determined. This is especially true of alfalfa, clover, and lawn grass seeds.

If the sample contains weed seeds, it had better be rejected for there are always weeds enough to contend with without sowing more.

Grains, clovers, and grass seeds are far more apt to have foreign seeds mixed with them than any other class of seeds as they are usually harvested by the wholesale, weeds and all, and it

South American Thistle

Mr. Burbank takes a great interest in the thistles. He believes that they are capable of being developed into useful commercial plants. Here is a South American species with which he is experimenting, first endeavoring to remove its thorns.

is only by careful screening that the other seeds can be removed. With seeds of hoed crops, such a condition does not exist.

It is impossible, of course, to give here a complete description of all the different kinds of weed seeds, but pictures are given in the natural color of some of the most common ones. By comparing the seeds with these pictures it will usually be possible to determine the kind of seeds that are found in your locality.

Of course, one must always expect to find a few foreign seeds in a sample of grain, but remember that the weed seeds cost the same price per bushel as the oats. That is, if the price is $2.00 a bushel for oats, you pay $2.00 a bushel for the weed seeds which are not only worthless but a detriment to the crop.

In orchards, especially in California, the two worst weeds are wild morning-glory and a new species of perennial amaranthus.

Both of these produce many long and persistently sprouting roots. The morning-glory sends its roots to great depths and has taken possession of many acres of the best land. This, of course, greatly reduces the production of crops and the value of the land.

The overrunning of a field is due to the fact that the owner of the land was careless in not

destroying the morning-glories when they first appeared. This weed spreads in all directions like a fire and its spreading is increased by ordinary cultivation, as small portions of the roots are carried by the cultivator to other locations where they soon grow into new plants.

It is extremely difficult to exterminate the perennial morning-glory in orchards and vineyards because the ordinary cultivating machinery does not run close enough to the rows. The only way to exterminate this weed is to spend all the time and labor necessary for one whole season in cutting off the plants before they appear above the surface. This may be done with a cultivator made with sharp knives that run under the surface. It will be necessary to go over the ground regularly at least once a week. If this pest is allowed to produce any foliage it gives the plant a new start.

The common amaranthus produces an enormous amount of small black seeds. It is an annual and is often called careless weed, because it is seldom found in abundance except on land that has been carelessly cultivated. Thousands of seeds are produced by a single plant and they come up during summer and thrive especially well on rich fertilized soils.

The common amaranthus, however, is almost harmless when compared to the new perennial

species which has lately been seen in many public grounds, and is rapidly spreading to farms and gardens. This new weed, unlike the annual, sends down long slender roots deeply into the soil and if cut off, no matter how deeply, will immediately sprout with redoubled vigor.

But this is not the worst.

Like the annual, its sole object seems to be to produce enormous quantities of seeds. This new pest trails instead of growing upright and begins to produce seed almost as soon as the plants appear above ground. This seed production is continued as long as the plant lives.

The only method of destroying this is to cut off the first plants which appear, and apply a small quantity of salt or sulphate of iron on the cut portion of the root, at the same time burning every portion of the plant removed.

Mustard, wild radish, and wild lettuce, though annuals, are often difficult to exterminate as they are abundant seed producers. The best method of exterminating these is to destroy each plant before they have time to ripen seed.

Usually it is possible partially to rid the land of them by plowing it thoroughly early in the spring and growing some cultivated crop.

Sheep sorrel or red weed, sometimes called "shamrock," is another most persistent weed, very

hard to exterminate if once established, especially in lawns and moist shady places. It is a persistent producer of runners, as well as seeds that are projected a great distance when ripe.

It seeds abundantly when the plants are quite young. When the seeds are ripe they are projected with great force in all directions. This is best exterminated by unremitting destruction with the hoe before the plants produce seeds.

There are numerous other smaller and more insignificant weeds such as shepherd's purse, several senecias, chickweed, and others which are not as persistent as those already discussed, but which should be kept well under control by thorough cultivation if good crops are to be produced.

It should be borne in mind that weeds are enormously prolific, and that their seeds go everywhere. So it does not suffice to keep your garden weeded and your lawn well mown. It is necessary also to pay heed to the weeds along neighboring roads for their seeds will be no respecters of your boundary lines.

You will be taking steps toward enhancing the beauty of your lawn next season, and will be lessening your work in the flower bed and vegetable garden if you use scythe and hoe freely on the weeds growing along the roadside everywhere in the neighborhood of your garden.

The Siberian Lily

This interesting Asiatic plant is under observation in Mr. Burbank's garden, and has been improved by selective breeding as to the form and size of its spikes of flowers. It is an attractive novelty on the lawn.

No effort that you could bestow would have a larger influence toward the beautification of your next season's lawn, and the lightening of your labors in next season's garden than that devoted to the destruction of this season's crop of weeds, wherever found.

Flowers; and the Disposition of Trees

Probably color is the most attractive thing about flowers. Usually solid colors are more attractive but harmonious combinations are almost as valuable.

A graceful form probably comes next in attractiveness.

Size and abundance of bloom next. Size does not always happen to be an advantage. Some flowers, as the heaths, are attractive because of the smallness of the blossoms. In this case the small size really adds gracefulness to the plant. Where the blossoms are small more are needed to make a good effect, so improvements on flowers with small blossoms should be made along this line where needed.

Everyone must be his own judge of harmony in the colors of plants. Most fairly well educated persons have a sense of harmony to direct them to the combination of colors to work for.

White is harmonious with all colors. A deep red is not harmonious with blue, except sometimes

with a pale blue. The sense of distinguishing harmonious combinations of colors has been more developed since aniline dyes were introduced. This is principally because with the aniline dyes almost any shade of color can be made. Before their introduction the unusual shades were not often seen.

All the prismatic colors are beautiful and attractive in their proper place. The delicate shades of each of these colors are even more pleasing to the average educated mind. Red is the most insistent color. Yellow and orange are next. White is insistent. Black is insistent.

In selecting flowers, I aim to pick those that are striking, harmonious, pleasing, and new in respect to color. In order to be able to select flowers for color one must be thoroughly familiar with all of the colors in each variety now in existence. Now that there are more people working for new varieties of plants it often happens that two or more persons will develop new varieties almost exactly alike at the same time. For this reason, it is usually more advisable to work with plants that are not so common. For instance, get seeds and slips from foreign countries, or take wild flowers and domesticate them.

Each new flower should be developed for some definite purpose. Red is an appetizer even to the

Japanese Magnolia

The magnolias are well known shrubs or trees of great ornamental value, owing to their very large and conspicuous flowers. There are a good many species, some of which are very hardy. The specimen here shown is a Japanese variety that Mr. Burbank has under observation.

birds. They will always eat the red fruit before that of any other color. Red flowers are good for the dining-room, and orange or yellow will serve the same purpose almost as well. Delicate shades are needed for the parlor, drawing-room, sleeping rooms, and libraries. A pale blue is very good, and pinks and combinations of pink and white are especially pleasing. It is also desirable to have a bright color occasionally in these rooms where more quiet flowers are kept. This gives a dash and spirit that is needed.

Practically all colors blend well with gray or brown as a background.

Flowers banked around the foundation of a house represent an unconscious exhibition of advanced civilization.

Vines give a peculiar grace to architecture and subdue unattractive colors. Green vines blend with any color.

Flowers harmonize with surroundings and subdue undesirable colors or forms. Borders of flowers break the hard angles between a building and the ground. Perpetual bloomers and perennials are especially good near buildings. The tall ones should be placed close to the buildings and the small ones in front. The small flowers are better for the beds on the lawn or near the street. It is not well to put taller plants in bunches in

front of the home. A single tall plant here and there sometimes lends an artistic effect. Usually when tall plants are placed near the road, it is best to have those with thin foliage.

Colors for yard planting should, of course, be those that attract the inhabitants. It is never, however, well to have a predominance of red. Flowers about the house serve to keep those living there in good spirits. They add a cheeriness that tends to keep people happy. White is always a good color. Blue is appropriate but must be accompanied by red or yellow, otherwise it gives a cold effect. Purples and deep crimsons do not always blend as well as other colors.

Hedges and Trees and Shrubs

The larger trees should be in the rear of the house. Fruit trees should be back of the house or to one side. The trees that shed their leaves should be on the south and east sides of the buildings. This leaves the evergreens to protect during the winter.

Trees with plenty of foliage should be planted on the southwest to protect the house from the hot sun in the summer. On large estates oaks and elms and the larger trees may well be planted even in front of the home. Evergreens, especially tall ones, should usually be set out rather sparingly. Do not put them too close to the house, as they

Chilean Wild Flower

Mr. Burbank has received hundreds of wild flowers from Chile, the major part of which are unnamed and unclassified. Here is one that shows interesting peculiarities of petal that distinguish it in almost any company and give it the interest of novelty. Also it is by no means lacking in beauty, as a glance at the picture shows.

keep out the sunlight and make the house dark. A number of evergreen shrubs are desirable to set off the place.

Palms are good in a warm climate. Palms must not be crowded for they will suffer from lack of light and air, and will get out of shape. Usually the best way is to plant an abundance of palms, and later thin out those that are not doing so well. Sometimes it takes a great deal of courage to cut out part of the trees, especially if some of them have become favorites, but it will be to the detriment of them as well as other trees if the thinning is not done at the proper time. Evergreen trees and evergreen shrubs should be allowed to grow close to the ground.

It may be of interest to add the names of a few of the more desirable ornamental trees and shrubs:

Trees for Street and Ornament: Arbor Vitae, Big Tree, Lawson's Cypress, California White Fir, Silver Cork Fir, Maidenhair Tree, Silver Pine, Douglas Spruce, Tideland Spruce, White Spruce, White Ash, Basswood, Birches, Kentucky Coffee Tree, White Elm, American Holly, Magnolias, Oaks, Maples, Walnuts.

Shrubs for Ornamental Planting and Lawn Decoration: Black Alder, Andromeda, Japanese Barberry, Button Ball, Spanish Bayonet, Choke-

berry, Flowering Dogwood, Inkberry, Jersey Tea, Laurels, French Mulberry, Pearl Bush, Wild Roses, Strawberry Bush, Sumach, Sweet Pepper Bush, Sweet Shrub, Wax Myrtle, White Fringe, Wistaria.

Shrubs for Windbreaks, Hedges, Berries: Black Alder, Arrow Wood, Mountain Ash, Common Barberry, Chokeberry, Coral Berry, Flowering Dogwood, Sweet Elder, Wild Grapevines, American Hazelnut, Huckleberry, French Mulberry, Russian Olive, Osage Orange, Wild Yellow Plum, Sassafras, Sweet Shrub, Waxberry, White Fringe, Witch Hazel.

—A very large part of the lawns of the United States is left to depend entirely on natural drainage and fails to produce what might be expected of it if provision had been made for adjusting the water supply.

Field and Flower Garden

Some Practical Hints for Their Betterment

MANY have thought that decreased yields are always due to the exhaustion of certain chemicals from the soil. This is not always the case. In fact, it is seldom that decreased yields are due to the lack of plant food.

Plant origination, the highest type of work with plants, has shown the underlying principles of soils and their use. The results of fifty years' work in getting big results from the soil are here summed up in such a way as to show the underlying principles of crop production.

These principles are applicable on every farm, and may be applied in increasing the yield of any crop.

Years ago farming and gardening were "hit or miss" performances. Farmers tried methods because some one else had used them, and but few of them knew the reasons for any of the operations.

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In order to understand how to select soils and how to secure the best results from them, one must know the underlying principles of productive ability of soils and the methods used by plants to secure food from them.

Farming is now considered a manufacturing process. As a matter of fact, a farmer uses more kinds of raw materials and produces more kinds of finished products than any other manufacturer. It is just as necessary that he select his raw materials with extreme care as it is that the manufacturer of machinery select the most durable kinds of wood and the strongest kinds of metal.

Farmers have sometimes been criticised for not using more fertilizers but this is not always a just criticism. Fertilizers are valuable in some cases, but often a better physical condition of the soil would make it possible for the plants to secure enough food materials to increase the yield materially without adding fertilizers.

Profit in crops depends upon the location of the crops grown, the use to which the crops are put, and the cost of fertilizing when fertilizing is necessary. There are other things which affect the profits, but these are the underlying factors.

No definite rules can be given about handling the soil, for each one must work out his own practice according to his own conditions.

The Scotch Broom

This is a plant known to the botanist as Cytisus scoparius. The specimen here shown belongs to the variety known as andreanus, and has been described by some botanists as Cenista andreana. The plant has become fairly popular in America, and it is a hardy and thrifty shrub, to be recommended for covering barren and exposed surfaces. Mr. Burbank has improved the variety by selective breeding.

The value of soil depends upon its texture, the elements it contains, the exposure, location, natural drainage, the availability of the elements required, etc.

A well-drained alluvial soil of fine texture is the most productive with the average crop. Furthermore, it is usually most durable in its productiveness. That is, its valuable qualities continue to manifest themselves year after year.

Other things being equal, a field located in a comparatively level valley or plain is more valuable than one on the side of a hill. Often the soil on the side of the hill is rather thin and there is always the danger of washing. Rains come and carry the most valuable part of the field into the valley below.

Of course, hillside fields are valuable for some crops. In fact, in some cases, where the soil is rich, even better results are obtained on the hills than in the valleys. This is especially true in California and semi-arid sections.

North and east slopes are usually best for late crops, but the south and west slopes are always better for early crops. A slope toward the sun even of only one or two inches to the rod makes a difference in earliness of a week or more. This has been proven by many experiments.

The northern and eastern slopes hold the

moisture longer but do not warm up so quickly. For this reason they are able to withstand drouth better, but never yield as early crops as the southern or western slopes.

A clay sub-soil a foot or more below the surface with a sandy surface layer is the ideal soil for fruit trees. In fact, such a soil is good for most any crop. If the sub-soil slopes sufficiently to drain off surplus water, such a soil will always produce good crops.

Chemistry and Physics of the Soil

Plants secure their food from the soil through minute hair-like appendages on the roots, known as root hairs. The roots thus serve only as canals. The root hairs collect the food.

Because of the extremely small size of these root hairs it is plainly seen that any food used by the plant must be thoroughly dissolved before being taken up. These root hairs are deciduous like the leaves, and only active to any extent where the leaves are in existence and active. All food taken up by the roots is secured in solution and this makes it necessary to keep the soil properly supplied with moisture.

The presence of the proper chemical elements and moisture, however, is not the only thing that is needed for the root hairs to do their work well. Air must be present in the soil or it will be impos-

An Improved Crown Vetch

This is a useful and attractive perennial shrub, growing in California and in the Southern States, but unfortunately not hardy enough for our Eastern and Northern States. There are several species, giving opportunity for cross-breeding experiments, and it is possible that hardier varieties may be developed.

sible for the root hairs to secure the necessary food for the plant.

The air in the soil must come from the surface so it is obvious that it is always necessary to keep the surface of the ground in such a condition that it will admit air. Thorough cultivation and deep plowing keep the soil in a loose condition.

In this connection an old English adage copied from The English Ploughman fits in well.

"It is not so tiresome to plow well, sir; your mind is interested."

Knowing that the plant's roots must have plenty of air, one enjoys stirring the soil deeply for he knows that by this method the crop will be increased.

Cultivation must be frequent because the surface of many soils has a tendency to become rather hard and compact.

We may consider that there are minute tubes leading from the surface down into the soil. When the tops of these tubes are closed by having the soil bake it is easy to see that the supply of air is cut off. Stirring the surface, then, makes a connection with the outside air.

Cultivation also goes far in keeping insects and diseases under control. Many insects' eggs and larvae and many disease germs are found in the soil. When the field is stirred frequently, these

are brought to the surface and exposed to the hot sun and thousands of them are thus destroyed.

Soil is of a very complex composition, and furthermore it is continually changing. A worm burrows into the soil and in his way replaces and rearranges thousands of soil particles.

As the root hair penetrates among the particles of soil it affects a change.

The passing of moisture from one particle to another makes changes which are of extreme importance from the standpoint of fertility.

Because of this everchanging condition, it is necessary to pay close attention to the cultivation in order to keep the conditions as near uniform as is possible.

A soil that is not given the proper care as to cultivation often holds its valuable food elements like a deposit in a bank that bears no interest.

Every business man knows that it is an extremely bad policy to allow resources to lie idle, but farmers too often do not consider the elements in the soil as resources.

There are three important ways to make available the supply of plant food in the soil: One is by stirring the soil so that the air makes it possible for the root hairs to secure the elements. Another is by supplying sufficient air and moisture so that the elements in the soil will be dissolved.

The Acanthus

This handsome specimen grows in Mr. Burbank's garden at Sebastopol. The plants of this genus are natives of southern Europe, and it has been said that the ornamentation of the Corinthian column was suggested to the ancient architect by leaves of this plant. Some species of acanthus are hardy as far north as New England.

And the third is by applying fertilizers which supply the plant foods needed, in an available form.

It does not always follow that when the yield of a certain piece of land is small, that land needs fertilizers. It is very often the case that the poor yield is due to poor seed or shallow culture, or other cause. If great care is taken in selecting seed from the highest yielding fields year after year, one will then know that when the small yield comes it is due to something else.

I do not mean to say that it is not necessary to fertilize, but I do mean to say that very often expensive fertilizers are added when a thorough stirring of the soil, drainage, or irrigation would accomplish the same result.

Soil that is producing fruit crops needs less fertilizing than that producing grain crops. The fruits contain such a large percentage of water that the essential elements of fertility are exhausted from the soil very slowly.

On the other hand, the grain contains a large percentage of the essential elements of soil fertility and it is necessary to add fertilizers to grain fields much more often than to orchards.

Now that the fertilizer manufacturers are under government supervision it is safe to use any good standard fertilizer on the market. Many ex-

periments have been conducted to determine the right element in which the soil is lacking and supply that alone.

The analysis of soils has often proven of value, especially in scientific researches, but it is not practical for the average farmer to have a chemical analysis made of his soil to determine what kind of fertilizer should be used.

In practically every case good barnyard manure gives excellent results. In the same way, a fertilizer purchased on the market usually gives the results desired. Because of the complexity of the soil and the complexity of the requirements of the plants so far as different elements are concerned, it is plain to see that it seldom or never happens that any one element is wholly eliminated from the soil at a time.

Sometimes an element which appears to be exhausted from the soil is merely in an unavailable form. The addition of other elements in such a case, although they do not seem to be needed, may produce the required results because they assist the unavailable elements in changing to an available form.

Nitrogen usually has the most immediate and pronounced effect upon crops when it is applied in fertilizers. Nitrogenous fertilizers always produce quicker results, and when it is desired to get

California Wild Fuchsia

The familiar fuchsias are known as hot house plants in the east, and they seldom attain any great size. But in their native tropical haunts there are some of them that attain tree-like proportions. In California, also, the fuchsia is a shrub growing to a good size, and serving a useful purpose as a permanent lawn decoration.

early crops, these are the ones to use, especially in the early part of the season.

Nitrogen is quite often in the form of ammonia in the fertilizer. Ammonia is very volatile and escapes into the air rapidly if not properly incorporated. A commercial product that has a strong odor indicates that the ammonia is escaping into the air.

Use a fertilizer when it is absolutely necessary, but make sure first that some cheaper process, such as cultivation, irrigation, drainage, or rotation of crops, will not accomplish the same result.

The physical condition of the soil in practically every case is more important than the chemical condition, that is, it has a more direct effect upon the crops.

Increasing Crops by Rotation

Many flower lovers have been dismayed at having a favorite collection of lilies almost entirely destroyed by insects. Such a disappointment can be generally prevented by moving the lily bulbs.

Great fields of grain, and large orchards of valuable fruit trees have produced smaller yields year after year until it was finally impossible to grow a profitable crop at all.

The remedy is rotation.

Each grower must be his own doctor, however. There is no short cut to profitable crop yields.

They are obtained by the man who understands the bad effects of growing the same crop on one field year after year, and who knows that these effects can be avoided by making a change in crops.

Every horticulturist and every agriculturist should study what follows carefully. It tells *why* failures come, and *why* rotation forestalls such failures.

There are at least four important reasons why rotation of crops is necessary.

In the first place, insects which often gather in great numbers about certain plants are destroyed, or at least their number is reduced when other crops are grown on the land. This is because certain insects are adapted to depend upon certain plants for their nourishment. Lilies and amaryllis are often almost completely destroyed by such insects as mites, small centipedes, wire worms, eel-worms, etc.

Absolutely new, uncultivated soils seldom are troubled. It is mostly in gardens where plants from various quarters are grown that difficulty occurs.

These pests gather around the lower part of the bulb and if the bulbs are left in the same place several years the insects often destroy them completely.

Blossom of Night Blooming Cereus

The improved plant on which this beautiful flower grew is shown in the frontispiece of the present volume. Unfortunately the night blooming cereus is too tender to be grown except as a hot house plant in the colder climates of the eastern states; but it thrives in California, and deserves greater popularity than it has attained.

Although this is not generally known it is the common cause for the destruction of lilies. Many have had beautiful lily beds exterminated and have been unable to determine the reason. Sometimes by transferring the bulbs to another location, if thoroughly disinfected before replanting, they can be saved.

If gladiolus bulbs, for instance, are planted in the same place year after year, they do not thrive.

Usually there are fewer and fewer bulbs as the seasons progress, rather than more, and those that are produced are much smaller than the bulbs originally planted. The plants are also less vigorous.

The third year the crop is almost a complete failure. It is necessary to practice rotation of crops with gladiolus.

The same thing is more or less true with most other bulbs, as most of them have a bitter poison or protective principle that repels these insects. Some of them, of course, are not quite so susceptible to the ill effects as others.

Various bacterial and fungous diseases also attack plants that are grown in one place year after year. These organisms, although they may not be entirely destructive the first year or two, gradually multiply and become a greater pest from year to year.

A Beautiful Flowering Cactus

This is the cactus known as Opuntia basilaris, a low spreading form that makes a very striking contrast with the giant spineless opuntias in Mr. Burbank's garden. The present species is too small to be of any value as a forage plant, but its flowers give it high rank as a border plant for the garden.

When trouble arises from this source the remedy is to rotate the crops or, in other words, move the crop infested to another location.

Fungous diseases are especially destructive in potato fields. The potato scale, blight, and wart are well-known diseases which can often be wholly or partially controlled by the proper rotation and the planting of uninfected seed.

The third cause for failures is the unfavorable condition of the soil produced by the toxic substances thrown off from the growing plants. Plants, like animals, give off waste matter which is not only useless but poisonous to the plant itself, and often to other plants of similar nature.

These toxic substances are often less poisonous, and in some cases are beneficial, to other crops. It is obvious that when waste products from a certain crop have accumulated in the soil for a number of years, that soil is not as well suited to the crop as formerly. A change of crops practically always results in a more profitable yield because the waste products of the first crop are often not injurious to the second one.

The fourth cause, which is far less common than the others, is exhaustion from the soil of certain elements necessary to plant growth.

It is very seldom indeed that any one of the elements necessary to plant growth is wholly

The Sea-Urchin Cactus in Bloom

There are several species of sea-urchin cactus, known to the botanists as Echinopsis. The propriety of the name will be obvious to any one who has seen a sea-urchin. The contrast between the stubby stock of the plant and its splendid flower is startling.

absent from any kind of soil. It does happen sometimes, however, that an element is not present in available form. The plant's roots, of course, cannot take up certain elements that are in such a form that they cannot be absorbed. When the supply of material in the form that can be used is exhausted, the plant does not thrive.

Quite often the failure of crops when it can be definitely attributed to the condition of the soil is due to an unfavorable physical condition rather than an unfavorable chemical condition.

Rotation of crops always has an important and essential effect upon the physical condition. When alfalfa, cow peas, clover, or some other legume is grown, the roots grow deeply into the soil and when another crop follows, the fissures or canals opened up by these deep growing roots are used by the roots of the new crop, besides storing considerable nitrogen. In this way it is much easier for the following crop to permeate the soil where there is plenty of moisture. The roots can develop much more quickly and with less effort than if the deep rooting crop had not been grown on the soil before it.

It is quite evident that the addition of barnyard manure has almost as much beneficial effect upon the physical and bacterial condition of the soil as upon its chemical condition.

The Camellia

This shrub was introduced many years ago from Japan, and has attained great popularity. It has double interest in that it is closely related to the shrub the leaves of which furnish the tea of commerce.

The effects of rotation are most astonishing as shown by the results attained especially in California when grain follows a corn crop. There is usually fully twice the yield secured from the small grain crop following a crop of corn than when small grain follows a crop of small grain.

No doubt, the cultivation given the corn during the summer has much to do with putting the soil in the proper physical condition for plant growth. This cultivation destroys more of the microscopic organisms which are injurious to plant life, and releases elements which otherwise would be unavailable.

With the present varieties of plants, it will probably always be necessary to practice rotation of crops. But when plants are developed which are resistant to the various conditions which have been mentioned, rotation will perhaps not be so necessary.

Already certain plants have been developed which are resistant to numerous diseases and insects. Varieties of grapes are grown which resist the attacks of phyloera, and apples which are resistant to the attacks of aphis are well known.

Peaches and almonds which are not subject to curl leaf have been developed.

Plums which are not affected by the brownrot and plum pocket are now on the market, also

Cactus Blossom

Although Mr. Burbank's spineless cacti have been developed as forage plants and for their fruit, they deserve a place in any garden for their flowers alone. Not only is the massed effect of these flowers superb, but the individual blossoms are beautiful to the last degree, as this picture testifies.

cherries, pears, walnuts, and perhaps chestnuts, which are resistant to blight.

Because of the value to be secured from crops which need not be rotated, too much emphasis cannot be placed upon the importance of developing new plants for this purpose which are resistant to the various pests.

It will almost always be found that in fields badly affected with some disease or insect there are one or more plants which are not affected as seriously as the rest of the crop. By selecting such plants and perpetuating them by seeds or division, a new variety may eventually be produced that is resistant to the particular disease or insect which caused the damage.

If resistant plants were developed many old field and garden soils which have become worthless for certain plants could be made to produce profitable crops. Such soils are quite often thoroughly infested with numerous insects and diseases and the failure of crops is due more to this than to the lack of proper chemical elements.

It is possible to get resistant varieties of vegetables, grains, flowers, and trees and the process is the same in all cases.

Nature practices rotation of crops in the forest. A forest of hardwood trees is almost always replaced by soft wood trees. After these have grown

Pink Borders

This picture of the residence of one of Mr. Burbank's neighbors at Santa Rosa is introduced as giving a very good illustration of a modest garden that has been made beautiful by use of pinks as border flowers. Such an effect as this may be produced with very small expense, and with a minimum of labor, by selecting any one of a rather large company of border flowers, to meet the conditions of soil and climate of the particular region in which you live. It would be difficult to suggest a way in which a similar expenditure of time and money could insure greater pleasure; and you are benefiting your neighbor and the casual passerby as well as yourself. By making such use as this of even common flowers, you become a public benefactor.

on the land for some years, they are replaced by hardwood trees. And so the rotation continues.

This is not intended to be a complete discussion on the rotation of crops. It is the principles which underlie the practice that are of the most fundamental importance.

It is impossible to suggest any definite kinds of rotations which will be applicable under all conditions. Each person must familiarize himself as much as possible with the underlying principles and determine the rotation that is needed under his own special conditions.

[End of Volume X]

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List of Direct Color Photograph Prints in Volume X

Palms

Petunias

Pinks

Poppies

Primrose

Scotch Broom

Spanish Broom

Sisyrinchium

South American Flower

Star Flower

Tecoma

Thistle

Tigridia

Verbenas

Vetch

Virginia Creeper

Wild Flower

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